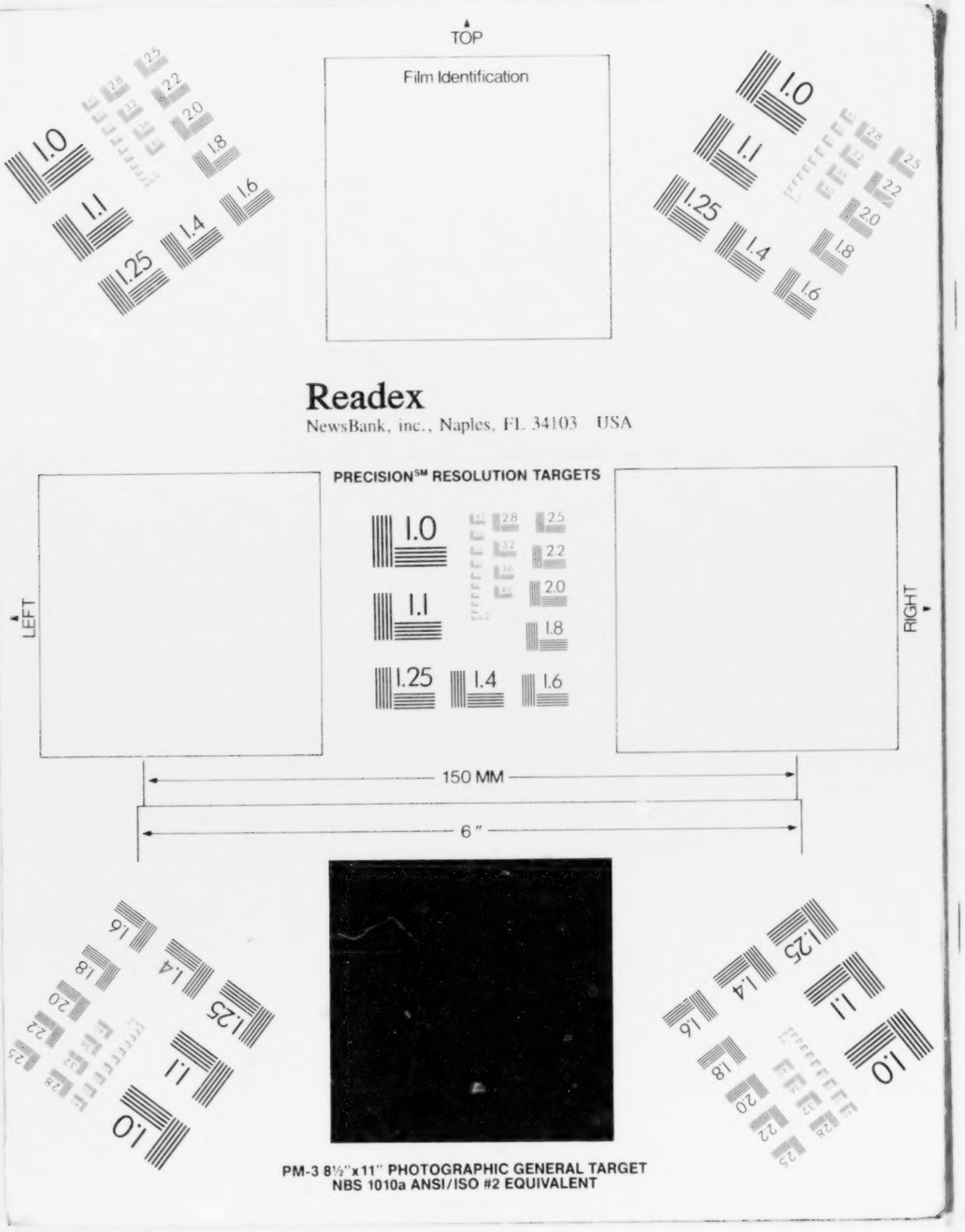

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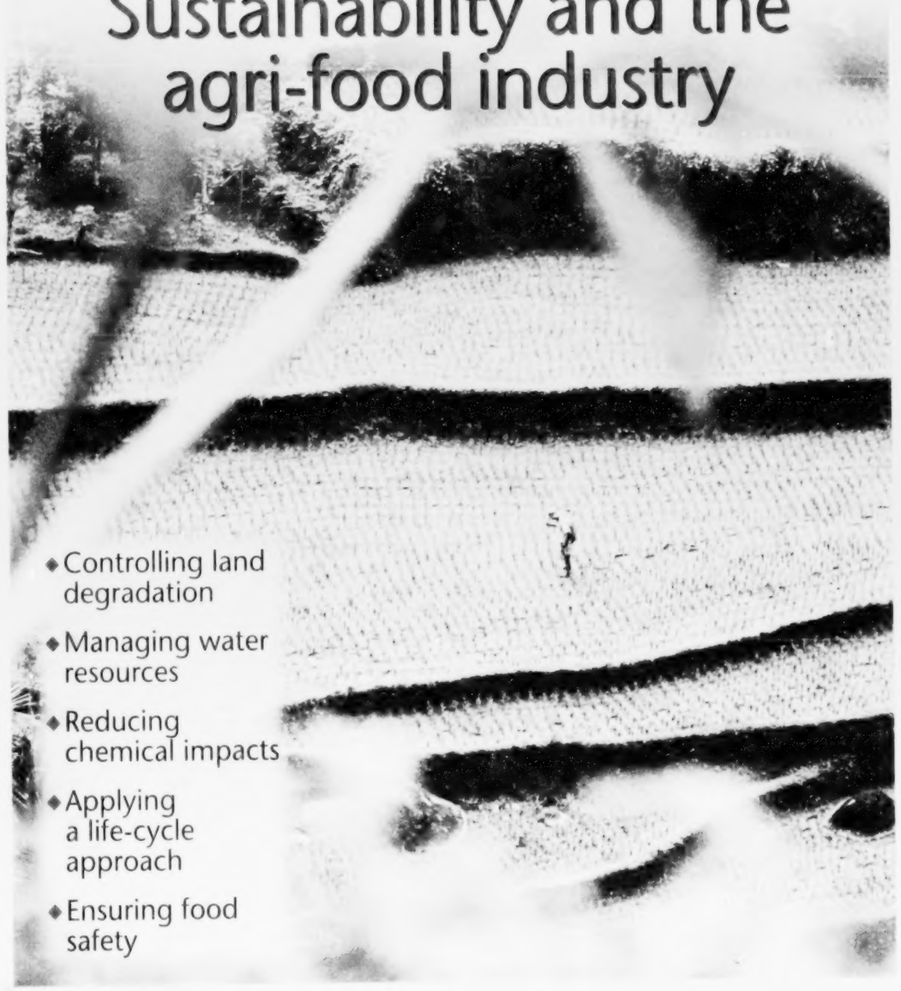
Sustainability and the agri-food industry



- Controlling land degradation
- Managing water resources
- Reducing chemical impacts
- Applying a life-cycle approach
- Ensuring food safety

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Making food production sustainable

Klaus Töpfer, United Nations Under-Secretary-General and Executive Director, UNEP

Meeting nutrition needs in a world where the population is increasing, the natural resource base is limited and fragile, and unsustainable production and consumption patterns are proliferating: this is the challenge for the 21st century! So far, human ingenuity has managed to strike the balance on a global scale – if often not regionally or locally. But the methods used have not been sustainable. There is a need to review in depth all the steps along the production, supply and demand chain.

With its land and water requirements, agriculture has a greater impact on natural resources than any other activity. To make agri-food production sustainable, we urgently need to address concerns about land and water use, productivity, consumption patterns, energy, and waste management. These related issues are very complex.

The world population will grow from 6 billion in 1999 to almost 9 billion in 2050, and this population must be fed. Pressure on land can therefore be expected to increase. Arable land per person has already shrunk from 0.24 hectares in 1950 to 0.12 hectares today. In many countries the situation is becoming critical. Pakistan, for example, has only 0.08 hectares of grain-producing land per capita and this figure is projected to fall below 0.03 hectares by 2050. Widespread land degradation is also a severe problem: according to UNEP's GEO 2000 report, it now affects up to 1.9 billion hectares world-wide.

Water tables are falling in North America, North Africa, the Arabian Peninsula and elsewhere. In India's Punjab, this occurs at a rate of half a metre per year; on China's northern plain, which produces 40% of the country's grain harvest, the rate is one to one and a half meters per year. GEO 2000 identified water shortages and climate change as the two most important environmental challenges of the 21st century. Water contamination from nitrates and pesticides, and salinization linked to poor agricultural practices, are major problems in many countries, including France, the Netherlands and the United States.

The tremendous growth of world trade also contributes to environmental problems. For example, a large part of industrial fishery production is exported. Overfishing by industrial fleets is responsible for the potentially catastrophic decline in oceanic fish stocks.

In short, with the global population expanding and incomes in many countries rising, water tables falling, cropland shrinking, and the oceanic fishery catch levelling off, it will be far more difficult to continue to increase world food production in the next half century than it was in the previous one.

Growing populations rely increasingly on food imports. This is especially true in developing countries, which are especially vulnerable to fluctuations in commodity and fuel prices. Agricultural subsidies in developed countries often encourage overproduction, wasting resources and depressing the prices farmers obtain on the world market. At the same time, higher incomes and living standards in developing countries are stimulating demand for meat and processed foods, with corresponding increased consumption of grain, energy and water.

To tackle these problems, there is an urgent need to improve our knowledge and make better use of existing solutions and environmentally sound technologies – particularly biotechnologies. Studies need to be carried out on the environmental effects and sustainability of various options for improving the environmental performance of agri-food production, and on identification of best practices. In particular, existing and emerging technologies must not be ignored. Some new technologies, such as those used to produce transgenic plants, need further assessment. The implications for sustainability of agricultural policies, including the use of subsidies, ought to be examined further. In individual companies or sectors, supply chain management and other tools (such as life-cycle assessment) are already contributing to an integrated solution. These tools need to be part of a broader sustainability strategy. More work is required to identify and fill gaps. Specific actions, such as substitution of safer alternatives for methyl bromide or use of energy- and water-efficient methods, have already proved effective. To implement these changes, however, many agri-food producers need technical and financial support.

There is room for vast improvement in the efficiency with which food is produced, even if only currently available technologies are considered. Increased use of approaches including drip irrigation, cleaner production techniques all along the production and consumption chain, energy-saving measures, packaging reduction and more efficient distribution can eliminate environmental impacts and production costs. Saving water is critically important: steps should be taken towards restructuring the world food economy through shifting to more water-efficient crops and more grain-efficient sources of animal protein such as poultry.

Strategies to improve eco-efficiency in food production will not succeed without changes in industrialized countries' consumption patterns. Consumer education is the key to these changes. Consumers need information on products' health effects and environmental performance, including inputs of water, energy and other resources. Price is a basic part of this information. Retail prices often do not reflect environmental costs. Better price signals and labelling allow consumers to make informed choices. More work is urgently needed to identify ways to encourage them to consider environmental costs in their purchasing decisions.

UNEP contributes to world-wide efforts to develop sustainable agriculture in a number of ways. It develops international agreements related to agriculture, like the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure, the treaty on Persistent Organic Pollutants (POPs), the Convention on Biological Diversity and the Biosafety Protocol. It promotes integrated crop management, integrated pest management and appropriate use of fertilizers. UNEP also contributes to the development of policies for improving the efficiency of water management, and to discussions concerning consumption patterns and trade issues affecting the environment. It encourages the use of tools like life-cycle assessment that can improve our knowledge and help us find sustainable solutions.

This issue of Industry and Environment focuses on just a few of the initiatives being taken to achieve sustainable food production. Addressing problems related to agri-food production will require continued examination of – and a life-cycle approach to – the intricate connections between agriculture, environment and development. UNEP is committed to contributing actively to world-wide efforts to find solutions to these pressing problems. ◆

Agri-food production Facts and figures

This issue of *Industry and Environment* looks at interactions between the food chain and the environment. Food is produced and consumed in a complex, interlinked series of processes. Every stage of production – from crop or livestock raising to transportation and storage, transformation through manufacturing processes, purchasing and consumption, and dealing with wastes – has environmental impacts.

Trends in world food production

Historically, we have relied on three essential food systems – cropland, rangeland and fisheries – for most of our food supply. Food production has expanded enormously in the past century, paralleling the three-fold growth in the world's population. The world grain harvest almost tripled between 1950 and 1990, from 631 to 1780 million tonnes; beef and sheep production also nearly tripled, from 24 million to 62 million tonnes. Fisheries production expanded even more dramatically in the same period, from over 19 million to over 85 million tonnes.[1] Since 1990, however, production of both grain and oceanic fish has levelled off (**Figure 1**).

Not only did the number of people in the world more than double in 1950-90, but the total amount of food per person also increased – by 20% between 1961 and 1994 (from less than 2000 calories per day in developing countries in 1962 to more than 2500 in 1995). This was due to a combination of improved grain varieties, greater fertilizer and pesticide use and irrigation, and rapid growth of food imports. Despite the global per capita figure, there have been significant regional variations (**Figure 2**).[2] Overall, however, there appears to be enough food for the world's current population. In fact, some calculations show that current food supply, expressed as calories per person, could feed about 12% more people. The most urgent problem, then, is not the amount of food but its distribution (**Figure 3**).

Potential long-term problems are indicated by trends in food production. As shown in **Figure 4**, grain yields increased in the 1990s at a much slower rate than in previous decades. But world demand for grain is still growing, partly due to a tremendous increase in consumption of animal products which in turn requires large amounts of feed grain.

What the rich and poor eat: grain, meat, fish

Grain production and consumption are the most significant measures of food supply, as they provide an indicator of nutritional adequacy. Grain consumed directly and in the form of livestock products ranges from just under 200 to over 900 kilograms. Much of wealthy countries' grain consumption is indirect, as it is eaten in the form of meat, milk, eggs and other livestock products. There remains a wide gap, in terms of consumption of livestock products, between developing and developed countries, even if developing country consumption is increasing rapidly (**Figure 5**). Meat consumption generally increases along with income and life expectancy. However, consuming more meat is not always associated with longer lifespans (**Table 1**). There is growing concern among public health officials about adverse effects of excessive consumption. The World Health Organization cites obesity and high-fat diets as a rapidly expanding threat to the health of populations not only in developed countries, but in an increasing number of developing countries as they adopt higher-income lifestyles.[3]

Fish accounts for about one-fifth of animal protein consumed globally. It is the primary source of protein for a billion people, mostly in developing countries.

Trade – where food is produced, where it is consumed

While the world's food trade picture is exceedingly complex, there are some broad patterns and trends. Increasingly specialized production has brought about a huge increase in global food trade, though North America and Europe are less reliant on imports for quantity and variety than are other regions. The developed world is a net exporter of food, while developing countries are net importers. The volume of trade in grains is far larger than that in meat. A large proportion of grain exports is produced by just a few countries and regions; the United States now supplies nearly half of world grain exports, with Canada providing another 10%. The greatest grain deficits are in Asia, which imported some 106 million tonnes of grain in 1995. IFPRI estimates that Asia's grain import needs will double between 1995 and 2020 (**Figure 6**). China alone will account for one-quarter of the total increase in global demand for grain by 2020.[4] It became a net importer rather than net exporter of grain in 1995. It has since fluctuated between minor net imports and exports, but is projected to need to import some 41 million tonnes of grain per year by 2020.[4] IFPRI notes that many factors, such as the Chinese government's investments in agriculture and variations in world grain prices, could significantly affect China's ability to meet its own grain needs. Africa also falls far short of producing enough grain for its own needs, and this deficit is expected to grow.

Many developing countries, including Indonesia, Thailand and Mexico, have seen a boom in earnings from industrial fisheries. Their foreign exchange earnings from fish exports increased by 87% between 1983 and 1993. However, industrial fisheries tend to produce high-value fish for trade to developed countries and low-value fish for fish meal, which is fed to livestock. While they provide employment, industrial fisheries tend to contribute far less to feeding low-income populations than do small-scale artisanal fishers, who account for most of the fish consumed directly in developing countries.[5]

Trade in agri-food products creates significant impacts through fossil fuel consumption, emissions, and additional processing and packaging requirements.

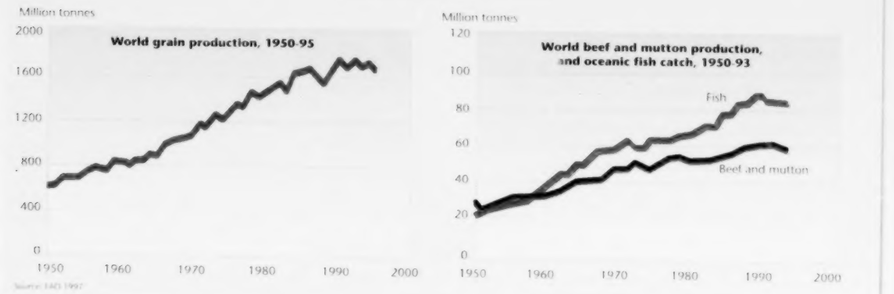
Environmental effects and cross-sectoral issues

Agricultural food production depends on the quality of natural resources, especially that of land and water. Agriculture can damage or enhance these resources. It is also sensitive to environmental damage from both agricultural and non-agricultural (e.g. industrial pollution, climate change) sources.

Agri-food production includes not only crop, livestock and fish production, but also food processing, transport, distribution, preparation and disposal. The effects of all of these must be considered and controlled if the food chain is to be made sustainable. A crop that can be *grown* with quite low environmental impacts, such as coffee, may be seen to have considerable impacts when assessments include processing wastes, the energy required for transport, roasting and brewing, and the impacts of production and disposal of paper cups and plastic stirrers. Life-cycle assessment, which considers all the steps in a food item's production and consumption processes, is a useful tool for examining environmental impacts throughout the food production chain. Among those whose impacts are evaluated are farmers, fishers, governments, industry (food processing, fertilizer and pest control), distributors, retailers and consumers.

Direct impacts of agricultural activities can include soil degradation, diversion of water resources, damage to or loss of land and aquatic ecosystems, and pollution from fertilizer run-off, pest control products and agricultural wastes. Many indirect impacts occur during power generation, transport of agricultural products for processing or sale, and production of fertilizers, pesticides and other crop protection chemicals, and farm equipment. Once food leaves the farm (or fishing boat), it may undergo manufacturing processes and packaging that produce further wastes. Canning, for example, consumes large amounts of water, packaging materials and power. Wastes can include heavy metals and solvents from cans, solid and liquid food

Figure 1
World food production trends



Source: FAO 1997

Rice: still the world's most important crop

Rice is the most important food crop in developing countries. It is the mainstay of the human diet in Asia, playing such an important role in people's lives that it figures in many myths and religious beliefs. It provides 29% of total calorie intake in the developing world and almost 40% of that in Asia. Rice is also a staple food in parts of Africa, where rising demand has led to a big increase in rice imports, and it continues to grow in popularity in other parts of the world.

Asia and the Pacific region produce and consume about 90% of the world's rice crop. Rice demand in this part of the world is expected to increase by 70% in the next 30 years, mostly because of population growth. In some countries, however, rising incomes will lead to lower per capita rice consumption, as more affluent consumers substitute higher-cost meat, fish and vegetables. Less than 5% of all rice production is traded internationally; the main rice exporters are Thailand, the US, Viet Nam, Pakistan and India.

As with other grains, the growth in rice yields has slowed in recent years. Meeting greater demand for rice will require bridging the gap between current yields and the yield required to sustain food security (see table). The potential for increased yields is especially great in the rain-fed growing areas that comprise 45% of all rice-growing land. Rain-fed crops now have an average yield of only 2 tonnes per hectare, compared to a theoretical maximum yield of 5 tonnes. In many areas, yields could be increased significantly through better use of improved varieties and techniques that are already available. Both traditional plant breeding methods and biotechnology also have potential to produce higher-yielding rice varieties matched to local growing conditions. Constraints on future increases include growing competition for land and water resources. Almost half of the land now used for shrimp farming in Thailand, for example, was formerly rice paddy.

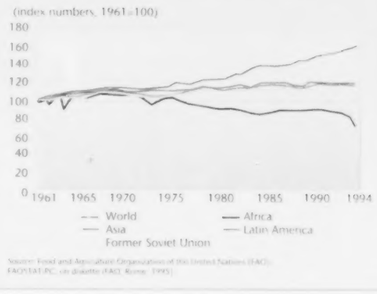
Source: IRRI

Maximum attainable yield and yield gaps in selected Asian countries

Country	% of rice under ecosystem				Yield in tonnes/hectare		
	Irrigated	Rainfed lowland	Flood prone	Upland	Maximum attainable yield	Current (1991-93)	Required yield to sustain food security
Bangladesh	35	35	23	8	5.4	2.7	5.8
China	93	5	0	2	7.6	6.0	8.9
India	45	33	7	15	5.9	2.7	5.4
Indonesia	72	7	10	11	6.4	4.4	7.4
Philippines	61	35	2	2	6.3	2.9	5.4
Thailand	7	86	6	1	5.3	2.1	2.3
Vietnam	53	28	11	8	6.1	3.4	5.6
Myanmar	18	52	24	6	5.1	3.0	3.7

Source: IRRI 1995

Figure 2
Trends in per capita food production, 1961-94



Source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT-PC, on diskette (FAO, Rome, 1995)

Food loss during and after production

A significant amount of food is lost during production, processing, transport and consumption. Food loss can occur for a number of reasons, including spoilage, pests and consumer waste. Rice provides an example of how this happens. The International Rice Research Institute (IRRI) estimates that 5-16% of rice disappears during harvesting (cutting, handling, threshing and cleaning). Another 5 -21% is lost in drying, storage, milling and processing. These losses may therefore account for 10-37% of all rice grown; later losses by retailers and consumers add to the total.

Estimated post-harvest rice losses in Southeast Asia

Activity	Estimated range of loss (%)
Harvest	1-3
Handling	2-7
Threshing	2-6
Drying	1-5
Storage	2-6
Transport	2-10
Total	**10-37**

Source: IRRI 1997

As the World Resources Institute (WRI) points out, "when 20% of a harvest is lost, the actual crop loss is just part of the problem. Also wasted is 20% of all the factors that contributed to producing the crop – 20% of the land used to grow the food and 20% of the water used to irrigate it, along with the human labour, seeds, fertilizer and everything else. In other words, post-harvest food loss translates not just into human hunger and financial loss to farmers but into tremendous environmental waste as well."[1]

Estimates of total post-harvest losses vary widely, in part because loss rates themselves can be quite different depending on crop, region, and climate, and because there are no universal measurement standards or efforts. Developing countries, located mainly in tropical zones, are particularly vulnerable to climate-related losses after harvest and during storage. Heat and humidity promote the proliferation of insects and microorganisms like yeasts and mould, loss of moisture content, degradation of food nutrients, and premature germination of stored seeds. Ironically, maize loss rates in some countries are often higher for high-yield varieties, as they have less-developed husks that leave the cobs vulnerable to pests and animals.

The problem appears to be especially great in poorer areas that often have low crop yields, relatively little mechanization of harvesting and processing, and primitive storage conditions. On the other hand, high losses often occur in the developed world because of consumer demand for cosmetically perfect produce. In the United States as much as 43 billion kg (27% of available food) is lost annually by retail operations, food service and consumers alone.

International trade also plays a role, allowing rodents and insects to migrate from regions where they occur naturally to new locations where there may be no natural predators or other controls.

Reducing food losses could add a significant quantity of food to the global supply, but the extent to which they can be reduced may be limited by the expense and effort involved. Some promising loss-prevention strategies focus on food storage, such as sealing storage containers against vermin or controlling humidity to prevent spoilage. Farmers might also be able to reduce losses by increasing mechanization, for instance replacing hand gleaning with mechanical harvesting for some crops. However, poor farmers, especially in developing countries, will often be unable to afford to make such changes. Governmental policies also play an important role in minimizing losses, particularly of commodity crops such as rice and corn; according to WRI, government policies can stimulate food producers to be more efficient and quality conscious by promoting a stable and sufficient supply of staple crops in an open, competitive marketplace.[1]

Sources: WRI, including figure; Michel Grolleaud, "Discovering the full story: overview of the phenomenon of losses during the post-harvest system," FAO, 1997; "Estimated Post-Harvest Losses of Rice in Southeast Asia," FAO, 1997.

wastes, thermal energy and waste packaging. Food products may be transported by a variety of modes, often in several stages and over long distances, requiring fuel and producing vehicle emissions. At every step energy inputs are required, with their associated use of resources and production of wastes and pollutants.

Wastes from agri-food production continue to cause environmental problems. Livestock production, especially on the industrial scale at which it takes place in many developed countries, has caused widespread contamination of surface and groundwater supplies. Highly processed and packaged foods also produce large amounts of waste; food-related packaging accounts for up to 70% of household waste in developed countries. According to a "business as usual" scenario, these problems can be expected to increase world-wide as developing countries' consumption patterns become more like those of the developed world.

Some of the impacts of agri-food production – land degradation, water-related impacts, chemical use and energy consumption – may have long-term repercussions on world food production capacity.

Land use and land degradation

Population pressure and poor agricultural practices have contributed to land degradation in many areas world-wide, threatening ecosystems and the land's future productivity. UNEP's recent GEO 2000 report presents a discouraging picture: though it notes the lack of reliable data, it appears likely that up to 1900 million hectares of crop and other land is affected, including 550 million hectares in Asia, 500 million in Africa, and 300 million in Latin America. An additional 5 million to 6 million hectares of cropland is taken out of production annually because of severe soil degradation.[2]

Soil erosion is a major cause of degradation: about two-thirds is caused by washing away of topsoil; the other third is wind erosion. A 1991 land degradation study estimated that topsoil was being lost 16 to 300 times faster than it can be replaced through natural soil-making processes. Farmland can also be degraded by mechanical tilling, which can cause soil compaction and crusting, by soil nutrient depletion due to poor management, and by over-application of agricultural chemicals that kill beneficial soil organisms. Poor water management in irrigated areas can cause soil to become waterlogged or salty.

A 1994 study estimated that soil degradation between 1945 and 1990 reduced world food production by some 17%, including by 8% in Africa and as much as 20% in some Asian and Middle Eastern countries. These losses can be expected to worsen as soil degradation continues.

Water use and water pollution

Both primary food production and food processing are critically dependent upon reliable water supplies and adequate water quality. Both types of activities can also have serious effects on water resources, which will be a critical factor in sustainable agri-food production. Shortages of potable water and agriculture water supplies, which now affect more than one-quarter of the world population, cause poor child and adult health and long-term damage to local economic viability. In many areas agricultural production is limited more by lack of water than by lack of land. Water resources in many parts of the world are being used far beyond their capacity for natural replenishment. Water scarcity can be more devastating and difficult to respond to than food shortages. It is more difficult and expensive to trade water among regions than to trade food or other products.

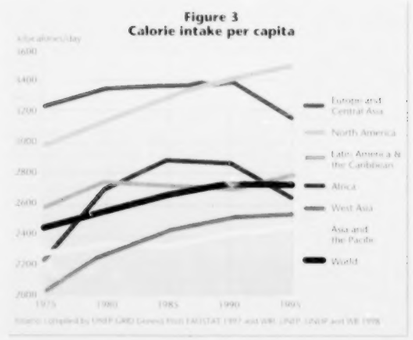
Table 1
Annual per capita grain use, consumption of livestock products, and life expectancy at birth in selected countries, 1995

Country	Grain use[1]	Per capita consumption				
		Beef	Pork	Poultry	Milk[2]	Life expectancy (years)
United States	800	45	31	46	288	77
Italy	400	26	33	19	197	78
China	300	4	30	6	5	72
India	200	1	0.4	1	34	60

(1) Rounded to nearest 100 kilograms. (2) Estimates based on FAO production figures for 1994.

Source: FAO 1995, UNDA 1994, Population Reports Bureau 1994

Figure 3
Calorie intake per capita



Source: Compiled by UNEP GRID Geneva from FAOSTAT 1997 and WRI, UNEP, UNDP and IUCN 1998

Agriculture accounts for 70% of all water use. Agri-food production has become increasingly dependent on irrigation (**Figure 7**), with irrigated land now producing about one-third of all agricultural products and one-half of all food. The amount of irrigated land (now approximately 250 million hectares) has nearly tripled since 1950. Increased irrigation is closely tied to the dramatic rise in food production during the same period. About 60% of the world's irrigated land is in Asia, which the UN Food and Agriculture Organization (FAO) predicts will also see two-thirds of future expansion in irrigated area. However, the rate of increase is declining because of increased costs, competition from other water users, and the global fall in real prices for food and agricultural products.

Irrigation is also associated with environmental impacts that may limit its potential for future expansion and productivity gains, notably soil salinization and waterlogging, as well as silt build-up behind dams and in waterways and reservoirs. These problems are expensive and difficult to reverse. They are exacerbated by inefficient water use, which in turn is often acceptable to agricultural users because they do not pay the full cost of the water they use. Because of traditional water rights patterns, government subsidies, and other factors, current water prices in many countries are so low that they often do not even cover the cost of delivery.

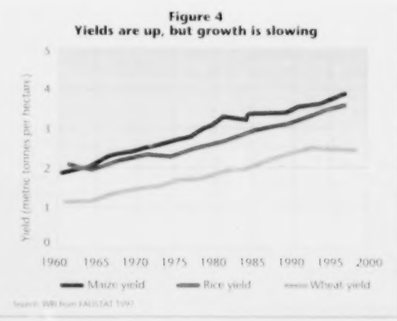
Agricultural practices and food processing operations have damaged ecosystems and degraded the water resources needed by growing populations. Water quality has been affected in many areas by intensive livestock production and improper use of fertilizers and pesticides. Animal wastes and most fertilizers contain high amounts of nitrogen, which easily passes into groundwater or runs off into surface water. Excess nitrogen often adversely affects the quality of drinking water supplies near live-stock production facilities and farms, as well as contributing to eutrophication of surface waters. Many pesticides contain toxic compounds that contaminate drinking water supplies and are harmful to humans and animals. The environmental impacts of using these chemicals can be controlled through integrated crop management practices, including appropriate fertilization techniques, water management, integrated pest management and proper farming practices.

Chemicals – fertilizers and pest control products

Many of the negative environmental effects of agri-food production are associated with chemical use, especially that of mineral fertilizers and pesticides. The use of mineral fertilizers, which has expanded tremendously since 1960 (**Figure 8**), is one of the factors contributing to the "Green Revolution" that has vastly increased global agricultural yields. However, yield increases in response to increased pesticide and fertilizer application are diminishing, and application of higher amounts of chemicals may merely lead to increased run-off into surface and groundwaters.

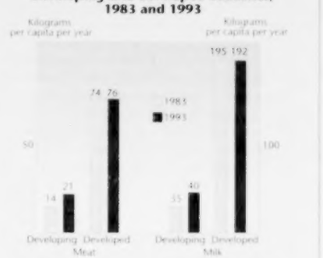
Despite the overall increase, fertilizer use has fallen in industrialized countries since 1989, partly because of reduced crop production in the former Soviet Union but also due to efficiency improvements. Many developing countries, in contrast, still have low crop yields that could be improved through additional fertilizer applications. Fertilizer use in developing countries is often constrained by low incomes, but its efficiency is also often low because of poor application practices. To be effective, fertilizers need to be applied at the right times and in the correct quantities and balances. If they are not, through ignorance or for other reasons, some or most of the fertilizer will be wasted and may harm the environment.

Figure 4
Yields are up, but growth is slowing



Source: WRI from FAOSTAT 1997

Figure 5
Per capita consumption of meat and milk, developing and developed countries, 1983 and 1993



Note: Meat includes beef, pork, mutton, goat and poultry. Milk is milk and milk products in liquid milk equivalents. Values are three-year moving averages centered on the two years shown.

Source: WRI from FAO 1998

There is increasing evidence that human addition of nitrogen, through fertilizers and many other pathways, is disrupting the global nitrogen balance. Animal wastes and fertilizers, with their high nitrogen content, account for most anthropogenic nitrogen loading; fossil fuels are a major source of atmospheric pollution from nitrogenous compounds. Nitrogen emissions, including fertilizers and animal wastes in run-off from agricultural areas, have caused widespread soil and water pollution and may contribute to global warming.

The nitrogen balance is highest in industrialized countries. Large areas of northern Europe, where there is intensive agriculture and high fossil fuel consumption, have very high nitrogen input rates. More nitrogen is added than can be absorbed by plants, and excess deposits are released to soil, water and air without any benefit to crops. Most of the excess nitrogen comes from animal wastes, but fertilizers are also implicated.[3]

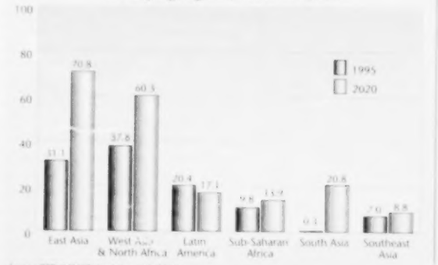
Other impacts may result from use of chemicals in food processing and packaging.

Energy and transport

Substantial amounts of energy are consumed in food production and preparation, while meat production requires much more energy (and water) per kilogram than crop production. The food sector now consumes about 10-15% of total energy in industrialized countries, though only 2-5% of total energy use (20-33% of food sector use) occurs on farms. Energy input for food production is relatively low compared to other industrial sectors. German and Swedish studies have shown that about 20% of total energy input to agri-food production is consumed by meat production; another 20% is used in home preparation. These figures are likely to vary greatly in less developed countries, but the trend towards increased meat production and consumption world-wide is likely to lead to considerably greater demand for energy if current practices and trends continue – with increased use of fossil fuels and possible climate effects.

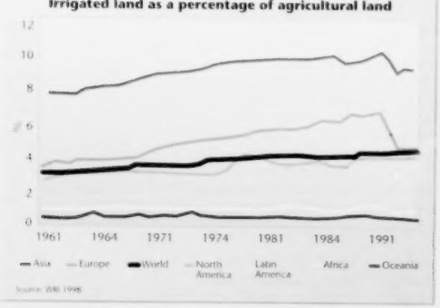
Transport activities related to agri-food production have widespread and serious environmental impacts, mainly due to air pollution from fossil fuels. The increasing volume of global agricultural production and trade also has impacts on land use, including through demand for more roads, distribution centres, port facilities and other infrastructure.

Figure 6
Net cereal imports of major developing regions, 1995 and 2020



Source: IFPRI IMPACT simulations, July 1999

Figure 7
Irrigated land as a percentage of agricultural land



Source: WRI 1998

Government agricultural policies and subsidies

Government agricultural and food-pricing policies can have enormous effects on agricultural production patterns and their subsequent environmental impacts. Subsidization of agricultural inputs such as water, electricity, fertilizers and pesticides have often led to their inefficient and environmentally damaging use. When subsidies artificially lower input prices, they can encourage overexploitation and waste of natural resources and other inputs. Government policies still generally exempt farmers from the "polluter pays" principle, allowing them to avoid paying the full costs of damage from pesticides, water resource degradation and other agricultural impacts.

The OECD recently carried out a study on the environmental effects of agricultural policy reform, focusing on the potential benefits and risks for the environment of making agriculture more market-oriented. Among the study's main conclusions was that farmers react to reductions in input subsidies and price supports by reducing their use of chemicals and farming less intensively. They tend to produce fewer crops on environmentally marginal land, with fewer nutrient surpluses, less grazing pressure, and lower risk of chemical and waste run-off to surface or groundwater. The OECD study found that policies that slow the conversion of wetlands, forests and grasslands to farming can preserve substantial natural areas, while afforestation and shifts from crops to grazing can help restore degraded soils. The study also recognized that farmlands can support varied ecosystems and contribute to land conservation; in these areas, abandoning farmland may be environmentally harmful.[8]

Looking to the future

The capacity of the three types of ecosystems on which mankind has historically depended for food – cropland, rangeland and ocean fisheries – to meet ever increasing food demands is limited. Oceanic fisheries and rangeland are essentially natural systems that appear to be reaching the natural limits of sustainable yield. Oceanic overfishing is now the rule rather than the exception, while rangelands' productivity has been seriously affected by overgrazing. Greater food demand must therefore be met largely through increases in crop production and in aquaculture. The uncertainty of population growth projections, and possible changes in consumption patterns, make future demand for agricultural products hard to predict. Nevertheless, the FAO projects that demand will roughly double by 2030.

Soya production and consumption

Soybean or soya, domesticated by Chinese farmers about 5000 years ago, has become the world's fourth-largest crop after rice, wheat and corn. The 1999 world soybean harvest is over 154 million tonnes, more than nine times greater than the 17 million tonnes harvested in 1950. In the United States, which is the world's biggest soybean producer, it is now the largest crop by harvested area and the second-largest by value. The US produces half the world's soybean harvest, while China produces 10%. Trade patterns have followed shifts in production: the US is the largest soybean exporter, and China is the largest importer, with two-thirds of its 4 million tonnes of soybean imports in 1998 coming from the US.

The tremendous growth in soybean production since 1950 – three times faster than the rate of growth of grain harvests – is due mainly to increases in the planted area. Soybeans are legumes that supply their own nitrogen, and yields are therefore not as responsive to the use of fertilizer as are those of cereal crops. Worldwide, the area planted to soybeans increased from 15 million hectares in 1950 to 72 million hectares in 1999.

Some soybeans are consumed directly by humans, for example in the form of tofu or soy sauce. But over 90% of the world soybean crop is used for non-food products, especially soybean oil and soybean meal. Soybean oil is the most important source of vegetable oil. Soybean meal is used as an additive in animal feed, and the rise in global – and especially Chinese – meat consumption has greatly increased demand for meal. Once a secondary soybean product, it is now more valuable than soybean oil. China is the second largest consumer of soybean meal, using 11 million tonnes in 1998, and demand in that country is doubling every five years. China's continuing growth in income, population and meat consumption is likely to fuel ever-greater demand for imported soybeans. The US is the largest soybean meal user, at 27 million tonnes annually. Other significant meal consumers include Brazil, France and Japan.

Source: Worldwatch Institute; FAO

Aquaculture

World aquaculture more than doubled from 1984 to 1994, and by 1995 almost 20% of all fish and shellfish production came from aquaculture. Aquaculture now provides 25% of all fish consumed directly by humans, and almost all farmed fish are used for human food. Aquaculture's contribution to fish supplies will increase in the coming decades as it expands and oceanic fisheries continue to decline. Asia is the leading aquaculture region, and China alone produces almost 60% of global production.

Most of China's aquaculture production consists of low-value species such as carp that are consumed locally, but in other areas high-value species, such as shrimp that are raised mainly for export to developed countries, dominate production.

Aquaculture's growth prospects are constrained by environmental factors. Fish farming requires both land and water, and these resources are already under pressure in many areas. Aquaculture operations have caused environmental impacts, including water pollution, loss of mangrove swamps and other habitats in Africa and Southeast Asia, erosion, exacerbated flooding, and salt intrusion into fresh water supplies. The other side of the coin is the threat that water pollution from agricultural and industrial sources poses to aquaculture operations. Run-off of nutrient-laden fertilizers from farms, for example, can feed algae blooms in aquaculture ponds, robbing them of the oxygen needed by fish and shellfish. Toxic chemicals in both farm and industrial run-off can harm or kill aquatic life.

There is also evidence that intensively farmed shrimp ponds remain viable for only five to ten years before they must be abandoned. Some 20,000 hectares of Asian shrimp ponds were abandoned in 1994 alone, and another 100,000 hectares may be abandoned by 2000. The pressure on coastal land resources created by the need for replacement pond locations could devastate large stretches of coastline in Thailand and other intensive-farming areas. These potential impacts raise questions about intensive aquaculture's viability as a sustainable food production system.

Another key sustainability issue for aquaculture is its impact on oceanic fish stocks. High-value, carnivorous species like shrimp and salmon need feed made from fishmeal, which in turn is produced from ocean fish. About two kilograms of fishmeal is needed to produce one kilogram of farmed shrimp or fish, resulting in a net loss of fish protein. To address this problem, Chinese researchers are working on yeast-based feed supplements that reduce the amount of fishmeal needed for aquaculture.

Sources: WRI, including table; FAO; Biksham Gujja and Andréa Finger-Stich, "What Price Prawn? Shrimp Aquaculture's Impact in Asia," *Environment* 38, N° 7, 1996; Solon L. Barraclough and Andréa Finger-Stich, *Some Ecological and Social Implications of Commercial Shrimp Farming in Asia*, UNRISD, 1996.

China dominates world aquaculture

Country	% share of global production, 1994
China	57
India	9
Japan	4
Indonesia	4
Thailand	3
United States	2
Philippines	2
Korea, Republic of	2
Other countries	17

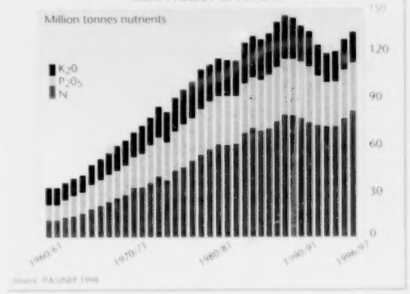
Source: FAO, The State of World Fisheries and Aquaculture, 1996, FAO, Rome, 1997.

Approaches to meeting this demand sustainably include increasing yields, expanding crop-producing areas, and making food production and consumption more efficient. Both traditional plant breeding techniques and new methods using biotechnology have great potential to increase yields, though probably not on the scale already seen in the 20th century. In the case of many crops, there is a huge gap between current yields and those that would be theoretically possible using all of the best available seeds, techniques, fertilizer and pest-control methods and other inputs.

Some of the articles in this issue of *Industry and Environment* address the environmental impacts of food production through analysing the production and supply chains of several sectors. Examples of effective approaches and good practices are provided. Issues such as energy and water conservation, chemical management and protection of biodiversity, which affect many sectors, are considered. Some authors discuss the policy considerations and management tools and practices needed to promote sustainable agriculture. Most of these articles examine certain aspects of the broader subject of agri-food production, which is vast, complex and interconnected.

UNEP is taking an integrated approach to this complex food chain. It is working to develop tools and information that will make possible more effective management of environmental impacts through focusing on the system as a whole.

Figure 8
World fertilizer consumption
from 1960/61 to 1996/97



Source: IFA/IFDC 1998

Notes

1. FAO, FAOSTAT database, 1999; US Department of Agriculture (USDA) Foreign Agricultural Service, *Grains: World Markets and Trade* and *Livestock and Poultry: World Markets and Trade*, 1999.
2. FAO, op. cit.; WRI, *World Resources 1998-1999*, 1998, ch. 10.
3. WHO, *Obesity: preventing and managing the global epidemic – report of a WHO consultation on obesity, 3-5 June 1997, Geneva.*
4. IFPRI, *World Food Prospects: Critical Issues for the Early 21st Century*, 1999, and *The World Food Situation: Recent Developments, Emerging Issues, and Long-Term Prospects*, 1997.
5. IFPRI, *2020 Vision News and Views*, October 1997.
6. UNEP/Earthscan, *GEO 2000*, 1999, p. 36-37; UNEP, *Global Environment Outlook*, 1997.
7. International Fertilizer Industry Association/UNEP, *The Fertilizer Industry, World Food Supplies and the Environment*, 1998.
8. OECD, *The Environmental Effects of Reforming Agricultural Policies*, 1998.
9. World Resources Institute, *World Resources 1998-1999*, chapter 9.
10. Ibid. ◆

Towards ecologically sustainable world food production

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Abstract

Improved production methods, and appropriate use of inputs and technology, can boost productivity in ways that are beneficial for the environment. Past successes in food production resulted in significant increases in per capita food availability, but they occurred in part at the expense of natural resources. Rapidly increasing yields reduced the expansion of agriculture into new lands and thus had positive effects on biodiversity, wildlife and soils. Negative impacts included the introduction of large quantities of chemical pesticides, as well as water and soil degradation. The key question for the future is not whether natural resources will be adequate to feed future generations, but whether the necessary policies and technologies will be introduced.

Résumé

De meilleures méthodes de production, ainsi qu'un usage judicieux des moyens de production et de la technologie, peuvent accroître la productivité sans porter atteinte à l'environnement. Les succès de la production agricole dans le passé ont permis d'augmenter sensiblement les ressources alimentaires par habitant, mais cela s'est fait en partie au détriment des ressources naturelles. La progression rapide des rendements a freiné l'expansion de l'agriculture sur de nouveaux territoires, ce qui a eu des effets bénéfiques sur la biodiversité, la faune, la flore et les sols. Les impacts négatifs sont dus notamment à l'usage de quantités massives de pesticides chimiques, avec pour corollaire une dégradation de la qualité de l'eau et des sols. La question cruciale pour l'avenir n'est pas de savoir s'il y aura suffisamment de ressources naturelles pour nourrir les générations futures, mais si les politiques et technologies nécessaires seront mises en œuvre.

Resumen

Los métodos de producción optimizados y el uso adecuado de las aportaciones y la tecnología pueden impulsar la productividad de forma positiva para el medio ambiente. Los resultados satisfactorios del pasado en la producción de alimentos resultaron en el incremento de la disponibilidad de alimentos per capita, pero se lograron en parte a expensas de los recursos naturales. La rápida multiplicación de las cosechas redujo la expansión de los cultivos hacia nuevas tierras, por lo que sus efectos en la biodiversidad, la vida rural y el suelo fueron positivos. Entre otros efectos negativos cabe citar el empleo de grandes cantidades de pesticidas, así como la degradación del agua y del suelo. La pregunta clave para la posterioridad no radica en si los recursos naturales serán los adecuados para alimentar a las generaciones venideras, sino en asegurarse de que se aplicarán la tecnología y las estrategias necesarias.

Introduction

In the next 20 years, the world needs to produce enough food to feed an additional 70 million people per year. It also needs to meet increasing and changing food demands related to rising incomes and changing lifestyles. These requirements will have to be met mostly through more efficient use of land already under cultivation, as significant expansion of cultivated area is not an economically or environmentally sound option in most of the world. The increase in food production should mainly take place in developing countries – not only to increase food supplies, but also to generate incomes and employment through agricultural and resulting economic growth.

IFPRI research suggests that the world is far from approaching the biophysical limits of global food production, but warning signs suggest that growth in food production has begun to lag and to severely tax natural resources. Increases in food production did not keep pace with population growth in many developing countries in the 1990s. The rate of growth of global grain production dropped from 3% in the 1970s to 1.3% in the 1990s, and the amount of grain produced per person has fallen in the past decade. Rice and wheat yields have been constant during the last few years in Asia. Production of the world's marine fisheries has peaked at 100 million tonnes and is now in decline.

The food supply picture varies across regions. South Asia and Sub-Saharan Africa are of special concern. The gap between production and market demand for cereals is forecast to widen from 1 million tonnes in 1990 to 24 million tonnes in 2020 in South Asia, and to triple to 27 million tonnes in 2020 in Sub-Saharan Africa. Unless poverty is significantly reduced, the gap between food production and need will be much larger. Sub-Saharan Africa in particular is unlikely to have the capacity to commercially import the difference between food needs and production.

The central challenges between now and 2020 are to develop the global capacity to produce adequate food in an environmentally sustainable manner, and to increase the capacity of poorer countries to produce food – not only to increase their food supply, but also to generate incomes and employment through agricultural growth.

Natural resources and agricultural inputs are critical determinants of food supply. Degradation of natural resources (soil, forests, marine fisheries, water) undermines production capacity, while availability of and access to agricultural inputs such as water, fertilizers, pesticides, energy and technology influence productivity and production levels. Appropriate policies and market incentives are essential for sound management of natural resources and agricultural inputs.

Soil

Concerns are growing about the extent and rate of soil degradation in the world and its effects on agricultural productivity and the preservation of natural resources, including biodiversity. In the past half-century, about 2 billion of the 8.7 billion hectares of agricultural land, permanent pastures, and forests and woodlands have been degraded. Of these, about 750 million hectares of mildly degraded land could be restored through good land husbandry measures, while another 900 million hectares of moderately degraded land could be restored through significant on-farm investments. Restoring the remaining 300 million hectares of severely degraded lands will be much more costly, involving major engineering investments. About 5 to 10 million hectares annually become unusable due to severe degradation.

Two-thirds of the world's degraded lands are found in Asia and Africa. Human-induced degradation is most severe in Africa, where 30% of the agricultural land, pastures, forests and woodlands is degraded, followed by Asia (27%) and Latin America (18%). Most of this degradation is taking place on agricultural and pasture lands, which are major sources of food, income and employment for rural people in many developing countries. Soil degradation has affected 75% of agricultural lands in Central America and 65% in Africa, compared with 25% in Europe and North America.

Most of the degradation is taking place in "breadbasket" areas (salinization), densely populated rain-fed farming areas (nutrient depletion and erosion), and areas with important environmental roles (water erosion in upper watersheds).

Overgrazing, deforestation, and inappropriate agricultural practices account for most of the degradation. To a large extent, these problems result from or are exacerbated by inadequate property rights, poverty, population pressure, inappropriate government policies, and lack of access to markets, credit and technologies appropriate for sustainable agricultural development. Crop productivity losses from degradation are significant and widespread in hilly areas, dryland cropping areas, rangelands and irrigated areas. Unless non-degraded soils are protected and currently degraded soils are restored, increasing population and persisting poverty will hasten soil degradation in the future.

Severe environmental deterioration is likely to occur in:

- the Indus, Tigris and Euphrates river basins, where continued salinization could threaten regional food security;
- the foothills of the Himalayas, where water erosion could exacerbate poverty and food insecurity;
- the highland areas of East Africa, where few ready sources of further productivity increases exist;
- the border zone between sub-humid and semi-arid areas in Africa, where migrations induced by dryland degradation could put additional pressure on the natural resource base;
- the forest margins of the lower Amazon, where overgrazing and nutrient loss are expected to worsen; and
- the periurban areas around Mexico City, where pollution from agricultural chemicals could worsen.

Soil fertility is a particularly serious problem in Africa, where lack of replenishment of nutrients is leading to rapid deterioration.

The use of mineral fertilizers will have to increase substantially in developing countries to meet food needs by 2020, although organic sources can and should supply more plant nutrients. Fertilizers also play a key role in enhancing the natural resource base.

Depletion of soil nutrients is a critical constraint on food production in Sub-Saharan Africa. The projected growth in fertilizer use will be inadequate, given nutrient requirements for food production and for resource conservation. Fertilizer applications are low because of high prices (resulting from thin markets, lack of domestic production capacity, poor infrastructure and inefficient marketing systems), insecure supplies, and the greater risks associated with food production in marginal areas.

Raw materials, capital investment and technology do not appear to be critical constraints on future fertilizer production. Negative environmental and health consequences of fertilizer use and production must be avoided. However, in most developing countries the problem is not *excessive*, but rather *insufficient* fertilizer use. The major challenge is to promote balanced and efficient use of plant nutrients from both organic and inorganic sources at farm and community levels to intensify agriculture in a sustainable manner.

Past and current failures to replenish soils with the nutrients removed must be rectified through balanced and efficient use of plant nutrients from both organic and inorganic sources, and through improved soil management practices. In view of the size and seriousness of the soil fertility problem in many low-income, food-deficit developing countries, policies providing incentives for farmers and communities to implement integrated soil fertility programmes are needed. Such policies should focus on assuring:

- clear, long-term property rights to land;
- access to credit, improved crop varieties, and relevant information about efficient fertilizer use in various production systems;
- efficient and effective markets for plant nutrients;
- investments in roads and rural transportation systems; and
- temporary fertilizer subsidies, where prices are high due to inadequate infrastructure or poorly functioning markets.

Fertilizer subsidies, which are not generally desirable or advisable, may be the only way to increase fertilizer use in some locations where it is most needed. In the longer term, fertilizer costs to farmers can be reduced and the need for price subsidies eliminated by investing in distribution infrastructure, providing innovative ways to share risks and finance, and encouraging regional cooperation for country-level fertilizer production facilities and procurement.

Forests

During the 1980s, about 0.8% (15.4 million hectares) of tropical forests world-wide were converted to other uses every year. Latin America had the largest area of forest converted during that period (7.4 million hectares every year), but other areas with smaller forest endowments had higher rates of forest conversion and carry heavier risks of completely losing their forest assets. Rates of forest conversion are highest in continental Southeast Asia and Central America and Mexico, averaging about 1.5% a year. Deforestation has important local and global consequences, ranging from increased soil and water degradation to greater food insecurity (especially among indigenous peoples who depend on forest products for food, fibre, medicines or income), escalating carbon emissions and loss of biodiversity.

Poor small-scale farmers clearing land for agriculture to meet food needs accounted for roughly two-thirds of deforestation in the 1980s. Such forest conversion, driven by food insecurity, will continue between now and 2020, particularly in Africa, unless farmers have alternative ways to meet food needs. And these needs will accelerate with population growth in rural areas. Commercial logging interests account for much of the remaining deforestation, especially in East Asia and West Africa. Although there is no consensus on the amount or location of forest that this generation should bequeath to the next, there is evidence that the world's forests are neither properly managed nor, when converted to other assets, sufficiently productive to allow future generations to meet their needs.

Marine fisheries

The world's fisheries are in crisis. Following a period of rapid expansion of harvesting from the oceans, more than a quarter of the 200 main marine fisheries world-wide are overexploited, depleted or recovering, while another two-fifths are fully exploited. Fisheries are collapsing in some parts of the world, and international disputes over fish stocks are increasing.

Resource management has failed to restrain the exploitation of natural fisheries beyond sustainable limits, leading to increasing conflicts as fish become more scarce. Even where access is restrained, most fisheries have too many fishermen with legitimate access. Within the next 20 years, fish catches will (at best) be no more than current levels, as losses from poor resource management and protection for some areas and species offset gains from better handling and exploitation of underused stocks. The challenge is to maintain the present levels of harvest from natural fisheries, while sustainably increasing aquaculture production.

Recognizing that natural fisheries are open access areas, the international community must develop and enforce a global programme of coordination and restraint to prevent exploitation of these areas beyond sustainable limits. International codes and regulations must allow for recovery of fisheries that have been overexploited, and must halt intensive use in areas where fisheries are fully exploited. Since takes from marine fishing are already far in excess of sustainable limits and economic efficiency, governments should reduce fishing in the short run and help fishermen move to other occupations.

Water

Enough fresh water is available world-wide to meet needs for the foreseeable future – if it were evenly distributed and appropriately used. But water is poorly distributed across countries, across regions within countries, and across seasons. Virtually all developing countries, even those with adequate water in the aggregate, suffer from debilitating seasonal and regional shortages. Competition for water is becoming more acute, increasing the potential for conflicts between sectors and water wars between countries.

Development of new water resources has slowed since the late 1970s. New sources of water are increasingly expensive to exploit because of high construction costs for dams and reservoirs, as well as concerns about environmental effects and the displacement of people. Investment in irrigation projects has slowed, especially in Asia, even though increased production from irrigated lands is likely to be decisive in meeting future food needs. Efficiency of water use in agriculture, industry and urban areas is generally low. Degradation of land and water resources through water-

logging, salinization, and groundwater depletion is growing. Between 0.3 and 1.5 million hectares of land is lost each year worldwide from waterlogging and salinization.

Pollution of water by industrial effluent, poorly treated sewage, and run-off of agricultural chemicals is a growing problem. Inadequate and unsafe domestic water supplies, compounded by inadequate or non-existent sewage and sanitation systems, are a major cause of disease and death (particularly among children) in developing countries. Inappropriate policies – distorted incentives and massive subsidies provide water at little or no cost to rural and urban users, encouraging overuse and misuse of water. Water for irrigation, the largest use, is essentially unpriced. The overarching challenge is to treat water as the scarce resource it is.

Growing national, regional and local water scarcities will depress agricultural production, worsen water-related health problems, degrade land and water resources, and catalyze water conflicts between users within a country and between countries. To address water scarcities, new water resources must be developed and better use made of existing water supplies. National governments should invest in carefully selected, economically efficient projects to develop new sources of water from dams and wells.

Because developing new water resources is expensive and potentially harmful to the environment, and because it may displace people from dam and reservoir sites, only a portion of rising demand can be met from new sources. A larger share of water to meet growing demands will have to come from more efficient use of water in agriculture, industry and urban areas. National governments must embark on comprehensive water policy reforms to improve incentives for users to save water, to improve procedures for water allocation, and to develop and disseminate better technology for water supply and delivery. Policy reforms must provide secure water rights, vested in individuals or groups of water users, in order to provide investment incentives, improve water use efficiency, reduce incentives to degrade the environment, and increase flexibility in resource allocation. In some countries and regions these rights should be tradeable, which would provide further incentive to conserve water. Irrigation infrastructure and management should be turned over to water use associations where well-defined water rights provide incentives for user groups to economize on water use. Governments must reform distorted price incentives, as well as reducing or removing subsidies on water to prevent its overuse or misuse. In estimating the value of water, the time women spend transporting it and the health benefits of drinking clean water should be evaluated. Regulatory instruments and market incentives should be introduced to conserve water, and to protect land and water resources. Governments should help make appropriate water conservation technology available.

The precise nature of water policy reform will vary from country to country, depending on underlying economic conditions and institutional capability, relative water scarcity, and the level of agricultural intensification. Water policy reform must also transcend national boundaries. In many regions, long-term solutions will require international cooperation between countries sharing scarce water resources.

Pesticides

Pre- and post-harvest losses in crop production due to pests are very large in developing countries. However, past practices of pesticide use cannot be sustained. Since 1945, global pesticide use has increased 42-fold to about 2.5 million tonnes today. Concerns are multiplying, in both developed and developing countries, that overuse or misuse of pesticides

- compromises human health;
- contaminates soils and water and damages ecosystems;
- suppresses species; and
- leads to pesticide resistance, pest resurgence, and the evolution of secondary pests.

Moreover, evidence shows that overuse of pesticides can lead to decreased food production. In Indonesia, the introduction of an Integrated Pest Management (IPM) programme in the late 1980s that combined biological controls and host-plant resistance with reduced use of chemical pesticides was associated with an increase in rice yields. Environmentally sound alternatives or methods of use must be developed and adopted. Available pest management means including host-plant resistance to achieve effective pest control with little or no negative environmental effects or health risks.

Energy

Agriculture consumes only 5% of global commercial energy. However, energy use in agriculture has grown significantly in recent decades because of

- increases in cropped and irrigated areas;
- rising mechanization in irrigation, land preparation and harvesting; and
- use of chemical fertilizers.

Chemical fertilizers alone account for almost 70% of developing country energy use in agriculture. Increasing agricultural production and agroprocessing in developing countries will call for substantial increases in the use of commercial energy. Still, agriculture will continue to be a minor user of energy.

Research and technology

Future food needs cannot be met using existing technology and knowledge. Attempts to do so would further degrade natural resources. Low-income developing countries are grossly underinvesting in agricultural research compared with industrialized countries, even though agriculture accounts for a much larger share of developing countries' employment and incomes. Their public sector expenditures on agricultural research are typically less than 0.5% of the value of agricultural production, compared with about 1% in higher-income developing countries and 2-5% in industrialized countries. Growth in public sector expenditures on agricultural research in developing countries has slowed to 2.7% per year in the past decade, compared with 7.4% in the 1960s. Many developing countries are even reducing their support for agricultural research. This trend has been under way for several decades in Africa (agricultural research expenditures per scientist have fallen by about 2.6% per year since 1961) and is more recent in Latin America. Further reductions in public investment in agricultural research will have severe consequences for global food production and natural resource management.

A focus on less-favoured areas

A large share of the world's poor, food-insecure and malnourished people live in rural areas with significant agricultural potential, limited and unreliable rainfall, and fragile soils. The land in these areas is often degraded and deforested. Increased public and private sector investments in infrastructure, market development, natural resource conservation, soil improvements, agricultural research, reproductive health services and family planning, primary education, and primary health care and nutrition programmes are needed in these areas. Although outmigration may be the answer for some areas in the long run, few countries are in a position to take in large numbers of mostly poor and poorly educated people between now and 2020. Moreover, outmigration merely transfers poverty and population pressure to urban areas and rural areas with better natural resources. Failure to address the problems within the areas themselves will accelerate degradation of natural resources and increase poverty, food insecurity and malnutrition.

In areas where current productivity is low but agricultural potential is significant, public policy and public sector investment should promote sustainable use of existing natural resources to enhance the productivity of agriculture and other rural enterprises. Governments, in close collaboration with local communities and non-governmental organizations, should establish and enforce clearly specified systems of rights to use and manage natural resources, including land, water and forests. Incentives such as partial coverage of costs should be provided to farmers and local communities to undertake activities to restore degraded lands. Local control over resources should be enhanced and enforced, and local capacity for organization and management should be improved. Public institutions responsible for managing and regulating publicly and privately owned natural resources must be reformed to increase user participation in management, and to provide incentives for private and community investment in and protection of resources. New forms of land- and other resource-improving investments, such as co-financing by local communities, government and private corporations, should be explored. Appropriate policies are needed to address the problem of externalities, in which the costs of a decision made by a person or group of persons may have to be borne by others. Such externalities, including failure to account fully for the effects of actions on future generations, may lead to another problem: inappropriate pricing of resources.

Efforts to preserve natural habitats should be pursued where this is critical to protect biodiversity, preferably in areas that are sparsely populated, have little or no infrastructure, and are of a size that can be effectively policed. Intensified agricultural production may be inappropriate for these areas. A moratorium on construction of infrastructure, particularly roads, that attracts new migrants to these areas should be considered. Farmers and communities can be encouraged to establish protected habitat areas (e.g. wildlife corridors) or to re-establish native vegetation along waterways or roads. Where protection of such areas presents clear international benefits, international contributions should support alternative sources of livelihood for the population in and around them.

Concluding remarks: win-win solutions

Much current debate about agriculture and the environment is based on the implicit or explicit premise that productivity increases in agriculture must necessarily harm the environment. That is a false premise. In fact, lack of productivity increase is much more likely to result in negative environmental effects. Improved production methods, and appropriate use of inputs and technology, can boost productivity in ways that are beneficial for the environment. The future challenge is to help farmers design and implement such win-win solutions.

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A whole of life approach to sustainable food production

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Abstract

Sustainability issues concern the entire food production and supply chain, from agricultural production and processing to packing, distribution and final consumption. Each of these steps involves input of resources and generation of wastes and emissions. This article explores some of the ways food production and consumption can be made more sustainable through greater resource efficiency, application of technology, consumer education, and better understanding of consumer demand. It also looks at how the food industry is responding to these challenges.

Résumé

Les questions de viabilité de la production alimentaire concernent la totalité de la filière de production et d'approvisionnement, depuis la production et la transformation, jusqu'à l'emballage, la distribution et la consommation. Chacune de ces étapes nécessite l'apport de ressources et entraine la production de déchets et d'émissions. L'article examine quelques-uns des moyens qui peuvent être mis en œuvre pour rendre écologiquement plus viables la production et la consommation des produits alimentaires grâce à une meilleure efficacité d'utilisation des ressources, à la technologie, à l'éducation du consommateur et à une meilleure compréhension de ses besoins. Il fait également le point sur la façon dont l'industrie agroalimentaire relève ces défis.

Resumen

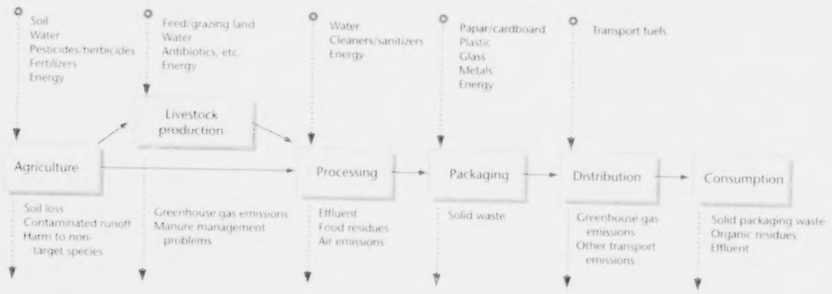
Los asuntos relativos a la sostenibilidad se aplican a toda la cadena de producción y distribución alimentaria, desde la producción agrícola y el procesamiento, hasta el empaquetado, la distribución y el consumo final. Cada uno de estos pasos implica el uso de recursos y la generación de residuos y emisiones. El presente artículo estudia algunas de las vías por las que la producción y el consumo de alimentos pueden hacerse más sostenibles, a través de un uso más eficiente de los recursos, la aplicación de la tecnología, la formación de los consumidores y más información sobre las demandas del consumidor. También contempla como hace frente a estos desafíos la industria alimentaria.

Perspectives on sustainability

Depending on where you live in the world, environmental sustainability of food production can have different imperatives. These differences are most obvious when comparing less developed countries and more developed ones, as their expectations and priorities are quite different. For less developed countries the ability to provide growing populations with the most basic food needs is the number one priority. Therefore, efforts focus on the essential requirements of production, such as access to a plot of fertile land, a good water supply, and the ability to distribute products to consumers. The intensity of production required to meet the needs of growing populations means that upstream production processes can have adverse impacts on the environment. In these regions, concerns about environmental sustainability focus on preventing the degradation of arable land and the loss of water resources.

In contrast, more developed countries are not generally faced with food security issues. Their problems are related to over-consumption rather than deficiencies. Due to higher levels of affluence, food is available in abundance and consumers' needs are focused on maintaining lifestyle qualities. Consequently, food is expected to be

Figure 1
Simplified representation of the food production and supply chain, showing inputs and outputs



safe, of high quality, available in abundant variety, and prepared and packaged in a convenient form. The downstream production processes required to meet these expectations place additional burdens on the environment as well as those generated by upstream food production. In these regions, sustainability issues are concerned with minimizing the resource intensity of downstream processing and packaging activities.

Irrespective of these different imperatives, the factors that ultimately govern the environmental sustainability of food production are common. Most nations face challenges in all these areas:

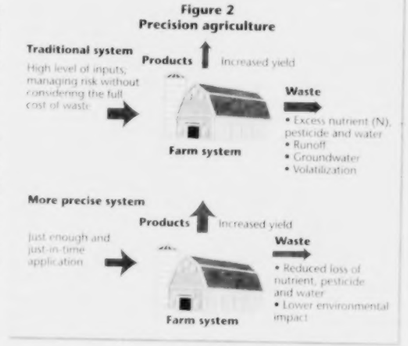
- conservation of soils and nutrient status;
- wise use of fertilizers;
- selection and preservation of productive genetic stock;
- careful use of agents for controlling disease and insect blight;
- efficient use of resources, in particular water and energy;
- protection of water quality through careful disposal of wastes; and
- minimization of wastes and productive use of by-products.

Sustainability issues cut across the entire food production and supply chain, from agricultural production to processing through to packing, distribution and final consumption. Each step along the chain involves the input of resources and generation of wastes and emissions. **Figure 1** is a simplified representation of the food production and supply chain, showing the inputs and outputs. At each step opportunities exist for optimizing the input of resources and reducing the generation of wastes and emissions. Initiatives taken by one sector within the chain can be dependent upon or provide benefits to other sectors. Therefore, a whole of life approach will be necessary for achieving environmental sustainability of the food production and consumption cycle as a whole. This article explores some of the ways that may be achieved – through greater resource efficiency, the application of technology, the education of consumers, and a greater understanding of consumer demand.

Resource efficiency and sustainability

Resource efficiency means using less to produce more. It is relevant to all aspects of food production: agriculture, intensive animal husbandry, processing, packaging and distribution. As the cornerstone of concepts such as cleaner production and eco-efficiency, it is probably one of the more widely recognized drivers for more sustainable food production, particularly in the food processing sector. At a recent conference on cleaner production (2nd Asia Pacific Cleaner Production Roundtable), altruism was not seen as the driving force for the implementation of resource efficiency. Speakers identified the financial savings to be gained from improved resource efficiency as a business consideration of growing importance. Many business leaders were already taking steps to improve all aspects of their environmental behaviour, including adoption of cleaner production.

Figure 2
Precision agriculture



In agriculture, resource inefficiencies can occur in water and irrigation management, nutrient and soil management, and pest and disease control. Environmental problems, which are a symptom of these inefficiencies, include erosion of soil, runoff contaminated with nutrients and pesticides, and harm to non-target pest species.

A study undertaken by the German Bureau of Sustainable Agriculture studied nitrogen inputs into German agriculture to determine production efficiencies (Isermann and Isermann, 1998). They found that nitrogen input was two to three times too high and resulted in a net biomass production that was only 25% efficient. This inefficiency caused emissions of reactive nitrogen into the hydrosphere and atmosphere that were two to eight times too high.

A number of techniques under the general heading of *Integrated Crop Management* (ICM) are evolving to help address some of these inefficiencies. *Precision agriculture* (**Figure 2**), for example, uses monitoring and mapping techniques to supply exactly the right amount of fertilizer, water or chemical control agents to crops at exactly the right time and place.

The processing of many food products inherently generates high levels of loss (**Figure 3**). For example, 50-60% of some vegetables can be lost during processing. Many other raw products, such as seafood and meat, have high levels of waste, particularly as the level of processing increases. Since food wastes are organic, they have traditionally been viewed as benign. Due to increasing production intensity, however, quantities of waste and pollutant concentrations can be very high. If not managed carefully, they can create significant environmental impacts.

Each sector – dairy, beverages, fruit and vegetable, starch and snackfood, bakery, meat and seafood processing, etc. – has its own specific wastes that are produced at different stages of the production pro-

cess. Often wastes can be minimized by the application of good housekeeping practices and best practices techniques. Some examples of resource efficiency opportunities for a selection of food processing sectors are provided in **Figure 4**.

A significant concern for the food processing sector overall is the use of water and the subsequent generation of effluent. Especially in some less developed countries, the discharge of food wastes with high biochemical oxygen demand (BOD) into open drains can cause considerable nuisance problems.

The packaging sector has also come under considerable pressure to be more resource efficient, particularly in relation to the design of packaging systems and the type of materials used. It is certainly achieving more through stronger and more lightweight packaging, and "take-back" provisions are in place in a number of jurisdictions.

Considering the energy content (**Figure 5**) and recyclability of different packaging materials can help make significant resource efficiency improvements in this area. The use of life-cycle assessment to justify packaging decisions will also have important repercussions for the packaging industry in the future.

Figure 3
Losses in food processing

Food sector	Indicative process losses (% wt)
Oils and fats	1
Dairy	1-5
Brewing	2
Biscuits and starch	5
Confectionery	15
Fish	40
Fruit and vegetable	50
Meat	76

Source: Kongshaug, et. 1994

Technology and sustainability

The "Green Revolution" in the agricultural sector is an example of the significant role technology plays in food production by dramatically improving the yields from staple crops such as wheat, rice and maize. The suite of technologies applied to agriculture has included modified seed varieties, monoculture systems, mechanization, petrochemical fertilizers, herbicides and pesticides, and irrigation. Such technologies have provided the ability for less developed countries to better feed growing populations, and for more developed ones to further enhance quality of life. However, the technologies have not been without their problems; for example, reliance on agrochemical-based pest and weed control, water management problems arising from the expansion of irrigation areas, and possible genetic erosion due to monoculture practices.

One technology that is evolving rapidly is biotechnology. In particular, the genetic modification of foods has leapt into prominence recently. The question of whether biotechnology is compatible with sustainable food production is highly contentious. Proponents stress the potential of biotechnology to reduce the need for chemicals and to improve the quality, safety, cost and convenience of food products. Opponents raise a variety of food safety, ecological, social and ethical issues. A healthy mix of both perspectives, as well as application of the precautionary principle, will be required to ensure that this technology remains a productive force.

Other traditional forms of biotechnology which involve the use of microorganisms for digestion and fermentation, etc. will play an increasingly important role in the area of food processing. This type of biotechnology has been used for centuries in making cheese, yogurt, bread and wine, but its role has expanded considerably to include by-product recovery, value-adding of wastes, and biological wastewater treatment. An example is the production of methane-rich biogas from the anaerobic digestion of organic waste streams, which can supplement fuel supplies. Other applications include production of lactic and propionic acids from whey, production of bioflavours from vegetable residues, and recovery of alcohol and specialty chemicals from starch wastes.

Membrane separation technology is another area that has significant potential for resource recovery in the food processing sector, and its applications are growing rapidly. Examples include the recovery of whey protein concentrate and lactose from dairy processing wastes, and recovery of protein from blood wastes using ultra- and microfiltration. Other physical separation techniques can be used to recover proteins and fats from meat and poultry processing effluents, fish oil from fish processing wastes, and citrus oil from waste citrus peels, to cite a few examples. Examples of chemical recovery techniques have also been reported, such as the recovery of chitin and chitosan from shell fish processing wastes. A summary of the above mentioned resource recovery applications is provided in **Figure 6**.

While many are still in the developmental stage, greater application of these technologies can be expected in the future. They will enable useful and potentially valuable commodities to be recovered from food and beverage processing waste streams. This may provide additional revenue for food processors, but it will also reduce the need for disposal of waste streams.

In the area of packaging and distribution, technology again has a role to play. A promising option for the long term is biodegradable packaging, for which there has already been considerable research and development. Starch-based packaging leads this field due to its relative cost effectiveness, but other forms of biodegradable

Figure 4
Resource efficiency opportunities for food processors

Meat and poultry plants

In most meat and poultry plants, large quantities of water are used for washing animal carcasses and for cleaning plant and equipment at the end of each shift. In poultry processing, water is also used for hot water scalding, in water flumes for transporting animal wastes, and for chilling birds.

Adopting dry cleansing practices, using spray nozzles on hoses and employing more efficient offal washing processes are key areas for saving water.

In poultry processing, more water-efficient processes and equipment include pneumatic waste handling instead of water flumming and the use of modern scalding systems. There are also opportunities for reusing wastewater, for example by using scald water overflow for plucking flumes and recycling chiller water.

Fruit and vegetable processing

In this sector, a considerable amount of raw material may be lost to the waste stream – up to 50-60% for some products.

Grading and sorting on-farm minimizes the quantities of reject material and dirt that are transported to the processing operation and allows for more efficient recycling back to the farm.

Greater integration along the supply chain, and controlling the temperature of the product from harvest to market using systems such as modified atmosphere packaging, are becoming important for maximizing quality and therefore reducing wastage.

Sourcing markets for lower grade products can also help reduce wastage in some instances.

Breweries

Consumption of hot water is an important area of resource efficiency for breweries. Hot water is produced from cooling the wort and is usually used for mashing. However, there is generally an excess of hot water which, if not utilized, represents a valuable loss of energy.

Breweries also have the opportunity to reduce energy consumption and energy-related emissions by improving the efficiency of their boilers.

Wastewater generated from breweries is particularly amenable to treatment by anaerobic digestion. This not only reduces the pollutant load of the wastewater, but generates methane-rich biogas which can be used to supplement fuel in the boiler.

Figure 5
Energy inputs for various forms of packaging

Packaging type	Energy input kcal/kg
Wooden berry basket	69
Styrofoam tray (size 6)	215
Moulded paper tray (size 6)	384
Polyethylene pouch (16 oz)	559
Steel can, aluminium top (12 oz)	568
Small paper set-up box	722
Steel can, steel top (16 oz)	1006
Glass jar (16 oz)	1923
Coca-Cola bottle, non-returnable (16 oz)	1471
Aluminium TV dinner container	1469
Aluminium can, pop-top (12 oz)	1643
Plastic milk container, disposable (2 l)	2159
Coca-Cola bottle, returnable (16 oz)	2451
Polyethylene bottle	2494
Polypropylene bottle	2752
Glass milk container, returnable (2 l)	4455

Source: Rowson, 1996

Figure 6
Resource recovery from food processing wastes

Biotechnology

- Lactic and propionic acids recovery from fermentation of whey
- Bioflavour recovery from fermentation of vegetable residues
- Biogas recovery from anaerobic digestion of food and beverage processing effluents
- Fuel alcohol recovery from starch

Separation technologies

- Whey protein concentrate and lactose recovery using ultrafiltration and monofiltration
- Protein recovery from blood using membrane filtration
- Protein and fat recovery from meat and poultry processing effluent using dissolved air concentration systems
- Fish oil recovery from fish processing wastes
- Citrus oil recovery from citrus peel pressing wastewater using vacuum distillation

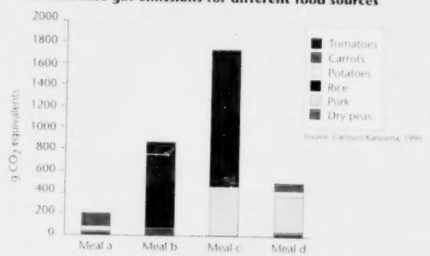
Chemical processes

- Recovery of phenolic food lipids from red grape marc using solvent extraction
- Chitin and chitosan recovery from the exoskeleton of crustaceans
- Collagen recovery from animal pelt

packaging include synthetic polyesters, naturally derived polyesters and polylactic acids. The latter of these may be produced by the polymerization of lactic acid derived from the fermentation of corn.

Another big growth area in packaging and distribution technology is smarter labelling systems. Sophisticated labelling systems linked to computer databases will enable produce and food products to be tracked throughout the distribution process. This will enable greater utilization of just-in-time systems along the entire food production chain, improving efficiency and ultimately resulting in less waste of resources.

Figure 7
Greenhouse gas emissions for different food sources



Emissions of greenhouse gases in CO_2 equivalents from four different meals with the same energy and protein content (2MJ and 22-24 g protein)

Meal a	Vegetarian meal with ingredients from domestic sources
Meal b	Vegetarian meal with some imported ingredients
Meal c	Meal based solely on animal-derived and imported foods
Meal d	Domestically produced food of both animal and vegetarian origin

Dietary choice and sustainability

The links between dietary choice and environmental sustainability are becoming more evident. Life-cycle assessment (LCA) is being increasingly applied to food products to compare the environmental sustainability of different food sources. For example, **Figure 7** shows the results obtained from a European life-cycle comparison of the greenhouse gas emissions from four meals of different food types and origins.

LCA studies such as these tend to indicate that animal-derived products are relatively more resource intensive and polluting than other food sources. As well, processing and packaging activities contribute most significantly to the overall impacts of highly processed foods. As can be seen from **Figure 8**, energy consumption increases with higher levels of processing. Domestically produced foods also have a lower overall impact than imported foods.

Consequently, some commentators advocate that people in affluent societies should be encouraged to eat lower down the food chain and to eat more simply. To minimize food impacts within the household, changes in diet may be one of the most important proposals for obtaining sustainable lifestyles in developed countries in the future (Carlsson-Kanyama, 1998).

Figure 8
Energy inputs for various processed food products

Product	Energy input (kcal/kg)
Ice production	151
Milk	354
Flour	484
Fruit and vegetables (canned)	575
Pet food	828
Wine, brandy, spirits	830
Ice cream	880
Meat	1206
Soft drinks	1425
Baked goods	1485
Fruit and vegetables (frozen)	1815
Fish (frozen)	1815
Cane sugar	3370
Dehydrated foods	3524
Breakfast cereals	15,675
Chocolate	18,591
Coffee	18,948

Source: Pimentel, 1996

For less developed countries, the most significant dietary related trend is the increase in demand for food of animal origin, which has been referred to as the "Livestock Revolution". Unlike the "Green Revolution", this has been a demand-driven trend fuelled by population growth, urbanization and income growth. People in less developed countries currently obtain an average of 11% of their calories from animal sources, compared with 27% for people in more developed countries (Delgado et al., 1999). This difference gives an indication of the dramatic changes in store for global food production. It is projected that by 2020 less developed countries will consume 100 million metric tonnes more meat and 223 million metric tonnes more milk than they did in 1993, dwarfing the increases in more developed countries of 18 million metric tonnes for both meat and milk (Delgado et al., 1999).

Considering the above mentioned reservations about the environmental sustainability of animal-derived products, the trend towards higher consumption of animal-derived food in developing regions has been identified by the International Food Policy Research Institute (IFPRI) as an important issue. The IFPRI believe that livestock can contribute to environmental sustainability in mixed farming systems that strike a proper balance between crop and livestock intensification. However, the higher numbers and higher concentrations of animals needed to meet the growing demands can lead to degradation of grazing areas, emission of greenhouse gases, and excess levels of nutrients.

Consumer demand and sustainability

Consumer demand is possibly the most powerful influence governing food production and consumption patterns, especially in affluent nations. Food products are seen by consumers as a bundle of attributes which include convenience, nutritional content, packaging appeal and others. With increasing affluence, consumers respond less to food prices and more to demographic factors, health concerns and short-term fads. Convenience and packaging can be as important to the consumer as content or price. Demographic and lifestyle trends such as greater numbers of women in the workforce, higher disposable incomes, and the introduction of cooking technologies (for example, the microwave) have contributed to this.

One apparent result of these trends has been the increase in levels of packaging (**Figure 9**). In most countries packaging continues to be driven by consumer demand, with regulatory bodies playing a limited role. In Europe, however, legislation and taxes on packaging have been established to encourage reduced packaging waste and more sustainable packaging practices.

The use of life-cycle assessment to examine

food products in relation to their environmental impacts will play an important role in educating the consumer and enabling decision makers to encourage the minimization of these impacts.

Food industry responses to sustainability

A number of trends identified by the World Business Council for Sustainable Development suggest a greater interest in the sustainability agenda by the business world in general (Schmidheiny et al., 1997). These trends are equally applicable to the food industry:

- Environmental regulations and enforcement are getting tougher;
- Some governments are encouraging self-regulation and partnerships with government agencies as an alternative to new environmental laws;
- Environmental groups and businesses are working together more to find solutions;
- Banks and insurers, concerned about environmental liabilities, are looking more closely at their clients' eco-efficiency records; and
- More investors are becoming interested in investing in environmentally responsible companies.

Sustainable Asset Management, a Swiss research company, surveyed 15 of the world's largest food manufacturers to determine how companies rated against a set of sustainability criteria (SAM, 1999). According to the survey, Unilever leads the way through its promotion of sustainable agriculture and fishing (**Figure 10**) and its efforts to make more efficient use of water. Unilever has also been producing environmental reports for several years. It was one of the first companies to be signatory to national packaging covenants. Raisio also rated well, as it reflected the desires of its consumers and deliberately avoided using genetically engineered raw materials, and is actively involved in developing environmentally friendly transport and packaging systems.

Not surprisingly, the larger international food companies have been the most obvious in responding to environmental issues. Astute chief executives of large companies are positioning these companies to take advantage of sustainability-directed trends and are banding together to push these trends along so that their companies will benefit sooner rather than later (Schmidheiny et al., 1997).

However, many others are taking less obvious steps to improve environmental performance through waste minimization, energy efficiency and cleaner production initiatives within their processing operation. For example, Asahi Breweries in Japan and the San Miguel Corporation in the Philippines are two food and beverage companies which have seen the benefits of using a cleaner production approach.

Small and medium-sized enterprises and industries in less developed countries generally lack the capital, executive time and room to manoeuvre to improve rapidly towards environmental improvements. These groups will need the impetus of improved government frameworks and of the larger companies, which many of them supply.

The Australian Food and Grocery Council recently undertook a survey of the environmental management practices of its member companies. Compared with similar surveys undertaken six years ago, there has been an increase in environmental consciousness and a higher number of executive staff are dedicated to environmental issues. It has also been observed that, in some instances, the managing director rather than the environmental officer has become the driver of environmental change. This implies a shift from a more compliance-focused approach to a more long-term and strategic one. Formalized reform of the industry has only just begun. Improvements are currently driven by reducing cost. They are only just starting to be identified as providing overall benefits to the company.

Figure 9
Some facts about packaging

- On average, the cost of packaging materials represents about one-fifth of material costs; however, in 10 out of 40 food industry sectors, packaging costs exceed the costs of the edible foodstuff ingredients (Connor and Schiek, 1997).
- For the soft drink industry, 55% of total material costs is spent on packaging materials (Connor and Schiek, 1997).
- Packaging accounts for an increasing share of costs for the food processing industry, from about 4% in 1947 to about 10% in 1987. Despite new materials that have reduced packaging weight, the total and relative costs of food and beverage packaging continue to rise (Connor and Schiek, 1997).
- Food packaging makes up about two-fifths of household waste (Senauer et al., 1991).

Figure 10
Unilever's response to environmental sustainability

Unilever, the Anglo-Dutch corporation, is committed to being responsive to the concerns of its consumers and wants to offer them the option to choose products from sustainable business practices. In response, Unilever, along with the World Wide Fund for Nature (WWF) has formed a conservation partnership to create marketing incentives for sustainable fishing by establishing an independent Marine Stewardship Council (MSC).

The MSC is an independent, non-profit, non-governmental membership body that has a broad set of principles for sustainable fishing and sets standards for individual fisheries. Only fisheries meeting these standards will be eligible for certification by independent, accredited certifying firms. Products from fisheries certified to MSC standards are marked with a logo on the packaging. This will enable consumers to select fish products from sustainable sources.

Unilever, which has 20% of the world frozen fish market, has committed itself to buying only certified fish by 2005. The MSC is looking for support from other organizations.

Source: A.D. Campbell, Director, Research and Engineering Division, Unilever Corporation (et al., 1997)

Conclusions

The world is changing, and with it food habits and patterns of consumption. Demographics are changing rapidly, and food production is one of the most obvious areas where the world has become globalized. Cleaner production concepts can be applied at all stages of the food production and supply chain – at the farm level, during processing, packaging and delivery, and even at the consumption stage. To achieve a sustainable food industry, we need to and can influence each process within the food chain through greater resource efficiency, the use of technology, consumer education, and having a better appreciation of emerging trends.

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The UNEP Working Group for Cleaner Production in the Food Industry

The UNEP Working Group for Cleaner Production in the Food Industry is part of UNEP's Cleaner Production Network, specializing in the application of cleaner production in the food industry. It was established in 1996, and is supported by and located at The University of Queensland in Brisbane, Australia.

The primary function of the Working Group is to help enterprises in the food industry profit from better environmental management. We endeavour to help companies identify and implement initiatives that achieve both bottom line improvements and environmental improvements. Our aim is to promote resource efficiency throughout the food production and supply chain.

A secondary function is as a clearing house for information and resources related to cleaner production information in the food industry. As well as information collected by ourselves, the group maintains a close working relationship with food industry experts from around the world. This places the Working Group in an excellent position to access and share information and experiences. In particular, the Working Group produces and collects cleaner production case studies that demonstrate the experiences and successes of innovative food companies; guidelines and fact sheets for the food industry; and regular reports and news stories from around the world.

The Working Group would like to further enhance its network of cleaner production practitioners and welcomes any contributions to its growing body of knowledge. If you would like to be part of the network or contribute to our resources, we would love to hear from you. A sub-group focusing on cleaner production in breweries has recently been formed. It is headed by Jacky Foo, who has extensive experience in bio-systems design, integrated systems and brewery waste product utilisation. For details, contact Jacky at *foo@swipnet.se*.

The third function of the Working Group is to provide consultancy services to industry and government clients, as well as education and training services at universities. Examples of recent work are:

- **Bakery Cleaner Production Assessment**: This project involved a site-wide waste audit to determine sources, quantities and costs of wastes generated at the site, and to identify cleaner production opportunities. A feature of this project was the involvement of staff and the incorporation of cleaner production into the company's operational objectives. Staff from all production areas received training in cleaner production. They subsequently took on responsibilities for recommending and implementing cleaner production solutions. The project also included the integration of environmental factors into the company's Key Performance Indicators.
- **Abattoir EMS**: An environmental audit was undertaken concerning all aspects of the company's activities, including meat processing, effluent treatment, effluent irrigation and wastewater treatment. The Working Group then prepared an Environmental Management System (EMS) for the operation.
- **Wet Waste to Energy**: A study was undertaken to identify those biomass-originated wet waste streams from food processing sites that have an energy value, and then to determine the most suitable techniques for harnessing their energy. The objectives were to identify any feasible methods of utilizing wet waste streams as renewable fuel sources, thereby reducing greenhouse emissions. The project included the development of feasibility case studies that assessed the potential for energy recovery at sites including a piggery, an abattoir (slaughterhouse), a poultry processing plant and a food processing site.
- **Case Studies and Assessments**: The Working Group has prepared cleaner production case studies for over 15 companies and has undertaken eco-efficiency assessment for over ten. The participating companies include bakeries, abattoirs, feedlots, soft drink manufacturers, dairy processors, aquaculture operations, fruit and vegetable farms and processors, and hotels and tourist operations.
- **Education and Training**: The Working Group delivers cleaner production courses for the University of Queensland and other institutions at both undergraduate and postgraduate level. It has also been a key stakeholder in developing the inaugural APEC Masters of Sustainable Development programme in conjunction with the Universities of Queensland, Sydney and Malaya this year. Training tailored to the needs of individual industries can also be delivered. In the past, such training services have been in the areas of environmental awareness, waste auditing, cleaner production and life cycle assessment.

The Working Group has also been actively involved in organizing and participating in international cleaner production conferences and workshops. Recent conferences that the Working Group helped organize were the 2nd Asia Pacific Roundtable on cleaner production in April 1999 in Brisbane, and the 2nd Asia Pacific Conference on Sustainable Energy and Environmental Technology held in June 1998 at the Gold Coast. A number of conferences specifically related to cleaner production in the food industry in Costa Rica, Brazil and Hobart, Australia, were also attended by a Working Group representative.

Whenever possible, the Working Group endeavours to work with less developed countries to raise the awareness of, and promote the uptake of, cleaner production. It also assists UNEP's cleaner production agenda by providing technical expertise. Over the last year, staff from the Working Group have participated in cleaner production workshops in Mauritius and Costa Rica, held seminars in Kuala Lumpur and Singapore, and carried out food industry consultancies in Egypt and the Philippines.

One of the most important challenges facing the Working Group is to maintain an active network of cleaner production experts in the food industry. We welcome all interested parties including consultants, personnel from the agricultural and food sectors, government extension officers and researchers, and food industry suppliers. Please link with us and others to form a strong and diverse network, with the aim of creating a more sustainable and productive food industry.

For further information, contact Marguerite Lake, UNEP Working Group for Cleaner Production in the Food Industry, Environmental Management Centre, University of Queensland, Brisbane, Queensland, Australia, 4072. Tel: +61 (7) 3365 1545, http://www.gensp.uq.edu.au/emc/CP/default.HTM.

Stewardship for safe and effective use of crop protection products

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Abstract

Through research and development, the crop protection industry develops technologies and methods that can contribute greatly to the goals of sustainable agriculture when used within the framework of Integrated Crop Management (ICM). Member companies take measures to ensure that development and production methods meet the highest environmental standards, as well as conforming to regulations at all levels. The crop protection industry's stewardship projects seek to ensure that crop protection products are distributed and used safely and effectively so as to favour agricultural production, and contribute to environmental protection in the developed and developing world.

Résumé

Grâce à ses activités de recherche et développement, l'industrie de protection des cultures met au point des technologies et méthodes qui, utilisées dans le cadre de l'ICM (gestion intégrée des cultures), peuvent apporter une contribution majeure aux objectifs de l'agriculture durable. Les entreprises de ce secteur prennent des mesures pour que les méthodes de développement et de production soient conformes aux normes environnementales les plus exigentes et respectent les règlements en vigueur à tous les niveaux. Les projets de bonne gestion mis en place ont pour but d'encourager une distribution et un usage efficaces et sûrs des produits de protection des cultures afin de favoriser la production agricole tout en contribuant à la protection de l'environnement, et ce dans les pays développés comme dans les pays en développement.

Resumen

Gracias a la investigación y al desarrollo, la industria para la protección de los cultivos está elaborando tecnologías y métodos nuevos que contribuirán considerablemente a alcanzar los objetivos para una agricultura sostenible al ser utilizados en el marco de la ICM (Gestión Integrada de Cultivos). Las empresas miembro están tomando medidas para garantizar que los métodos de producción y desarrollo respetan los más altos estándares medioambientales, al tiempo que se atienen a la normativa en todos los aspectos. Los proyectos de gestión industrial para la protección de los cultivos se consagran a asegurar que los productos resultantes de estos cultivos se distribuyen y se emplean de forma segura y eficaz, en beneficio de la producción agrícola y para contribuir así a la protección del entorno, tanto en el mundo en desarrollo como en el desarrollado.

Committed to sustainable agriculture to meet the needs of a growing world population

GCPF represents about 90% of the world-wide crop protection industry in over 75 countries and their regional associations in the Asia-Pacific region, Africa/the Middle East, Europe, North America, Latin America and Japan. GCPF promotes the safe, effective and judicious use of crop protection products implemented within the framework of Integrated Pest Management (IPM) to help ensure adequate yields of high-quality food, feed, fibre and other useful products.

GCPF and its member companies and associations fully support the aims of sustainable agriculture and sustainable development and see it as their task to contribute to meeting this global challenge. One of the crop protection industry's primary tasks is therefore to help farmers achieve and maintain an adequate standard of living by safeguarding their yields.

GCPF also contributes to sustainable agriculture through the research carried out by its member companies: in 1998 alone, they invested 10% of their turnover in R&D. New products are developed to be incorporated into Integrated Crop Management (ICM), a whole-farm strategy to manage crops profitably, with respect for the environment, in ways that suit local soil, climatic and economic conditions.

GCPF members are committed to finding the right balance between protecting crops and safeguarding the environment. GCPF and its member associations therefore organize stewardship programmes to promote environmental protection and the socio-economic well-being of rural communities.

GCPF's commitment to sustainable agriculture extends from the laboratory to the destruction of any waste products resulting from the use of crop protection products. It is this life-cycle approach, coupled with a strong belief in the need for multi-stakeholder involvement, that is helping make an impact on rural communities around the world.

IPM – balancing the forces of nature to avoid crop yield losses

Integrated Pest Management (IPM), as defined by the International Code of Conduct of the Food and Agriculture Organization of the United Nations (FAO), is a "pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economically unacceptable damage or loss." As such, it meets the requirements of sustainable development and agriculture.

IPM programmes consist of three major components: prevention, observation and intervention. Some pest infestations can be prevented by growing appropriate crops for the location, rotating crops, using pest-resistant and herbicide-tolerant crops, using proper soil tillage, providing habitats and refuges for beneficial insects, seed cleaning, and careful harvesting and storage. Observation means monitoring pest populations carefully to determine the proper time and form of treatment. Intervention entails choosing the right measure or mixture of methods and products to reduce damage by pests, weeds and plant diseases to acceptable levels.

All GCPF member companies and associations have signed a declaration stating their support for IPM and their intention to support its implementation through both product development and cooperation with other stakeholders in the elaboration of IPM strategies. The widening of the portfolio of available pest control technologies to include mechanical methods, biology, chemistry and, most recently, biotechnology parallels the development of IPM; rather than focusing on specific products, the crop protection industry increasingly helps farmers find the best customized service package to solve a given pest problem.

Widespread implementation of IPM is also promoted by a multitude of consumer and environmentalist groups, donors, aid agencies, governments and NGOs. IPM is being incorporated into the regulatory policies and strategies of governments, donors and development agencies.

The crop protection industry's experience, resources, products and infrastructure can assist in implementing IPM in order to manage pests, weeds and plant diseases in a sustainable way.

However, it is essential to continue reducing user exposure to crop protection products, improving standards of work practice, limiting residues in the environment and in harvested

Cabbages are inspected at one of Thailand's royal-sponsored farm projects

crops, and avoiding potential problems of pesticide resistance. This is why the crop protection industry also provides expertise and training on safe and effective use of crop protection products, crop knowledge, control thresholds and crop monitoring, among others.

Careful and timely application of crop protection products is a fundamental principle of IPM. In the past, farmers were encouraged to apply crop protection products on a routine calendar schedule. Today's farmers are encouraged to monitor pest populations or the damage they cause and to use a product only when specific thresholds are crossed.

IPM is not a rigidly defined form of crop protection, but a dynamic system that is flexible and makes sensible use of the latest research, technology, advice and experience.

Ultimately, IPM will only be implemented by farmers and others trying to control pests if it is practical and adds value to their activities. GCPF member companies and associations in Africa, the Asia-Pacific region, Europe, Latin America and North America are dedicated to providing the information and practical solutions that make the benefits of IPM clear.

Case study: wild flowers return in field margins

The outermost six metres of conventionally grown crops at the 5000-acre Manydown Estate farm in Berkshire, England, has been planted to encourage the return of wild flowers. The consequent increase in seeds and benign species of insects has provided enough food for large increases in populations of wild birds, butterflies and pest-predatory insects.

On these conservation field margins owner Richard Stirling avoids using broad-spectrum weed killers and nitrogen-rich fertilizers. Instead, he uses very specific weed control chemicals only when pest predators reach such proportions that they threaten crop yield. The number of useful predators has increased to such levels that he has cut out the use of any insecticides during summer on any crop, including wheat, barley, peas, oilseed rape and grass for the beef cattle which supply the farm's butcher shop.

Says Stirling: "I believe we have developed a farming system that addresses many of the conservation issues that face modern farming today."

More than 2000 miles of field margin are now managed this way, thanks in large part to a three-year research project financed by the British Agrochemicals Association, English Nature and the Game Conservancy Trust to help establish this practice throughout Britain.

The Safe Use Initiative: technology meets community development

Throughout the research, development, formulation and distribution chain, the crop protection industry has direct control over safety matters. Once the product reaches the shelf, however, the level of control diminishes considerably.

This is why, in 1991, GCPF launched Safe Use Pilot Projects in Guatemala, Kenya and Thailand to overcome the obstacles preventing safe use. Pictograms have been developed to help reach illiterate farmers, and school programmes make it possible for children to take important messages about the proper use of crop protection chemicals home to their parents. Extension programmes have multiplied the qualified personnel available to give technical advice. Local communities have been encouraged to redesign protective clothing to take into account expense, climate and culture; for example, women in some parts of Africa have incorporated long skirts into their protective clothing because of taboos against their wearing trousers.

GCPF works closely with national, community and health authorities. Local capacity building initiatives include training farmers, farm labourers, doctors, school children and agrochemical dealers. Consultants, teachers and doctors participate in train-the-trainer schemes. The projects seek to protect people and the environment, prevent and treat personal contamination, recycle and/or dispose of empty containers safely, enforce regulatory legislation, and create local expert poison centres. National crop protection associations draw on the global network and share best practices on regulatory systems with their national governments.

The crop protection industry strives to influence users to act responsibly, which means getting involved in education, training and community and rural development. As farmers adopt the Safe Use principles, they discover the economic and environmental benefits of properly used crop protection products.

"Now I am using agrochemicals in a cost-effective way and have been able to increase my yields and save money," says Jayampathi Kumarisinghe, a farmer from Sri Lanka.

Guillermo Pacheco, a Latin American environmentalist, adds: "I think these programmes help awaken an ecological conscience in the people who use agrochemicals to control pests. The lack of knowledge about their correct use has provoked problems that are often blamed on the products themselves."

Good results have led to the extension of the SUI to other countries in Africa, Asia and Latin America, always in cooperation with governments, NGOs and international organizations, as well as the private sector.

Case study: Guatemala – progress on the ground

While Guatemala had the highest safety standards of the three pilot countries, research revealed local weaknesses in safety at both farmer and retailer level, requiring advanced training and certification schemes and more effective poison control centres.

Advice and materials on personal protection and the disposal of waste and empty containers were a priority. To create a multiplier effect, 800 government extension workers were trained, with a special focus on rational pest management. They now train farmers, dealers and housewives, who in turn share their knowledge with employees. This has been backed up by the production and distribution of protective clothing, radio programmes, posters, brochures and flip charts. An accreditation scheme for retailers was introduced with government support.

In this Central American country, two-thirds of the population lives in rural areas and children help their parents in the fields, especially during school holidays. A creative programme of audio-visual material – slides, pre-recorded cassettes and booklets – featuring a friendly, colourful scarecrow ensures the important messages get across to this very important audience.

Through the Ministry of Health, many doctors and paramedics receive special training. A computerized database has been set up to monitor suspected poisoning incidents. More than 20 hospitals and health centres have already been equipped with antidote kits for a rapid response to personal contamination cases.

The second phase of the project focused on small vegetable growers, with a more personal approach including field visits and demonstration plots. One "master trainer" now resides in each target community to coordinate the efforts of extension workers, agricultural guides, home educators and teachers. Today the project is financially self-sufficient due to a small levy on imports.

Safe Use programmes, organized by other Latin American national associations through cash and in-kind contributions, are now operating in Argentina, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Honduras, Mexico, Nicaragua, Panama and Venezuela.

Prevention is better than the cure: managing stocks of crop protection products

Preventing the unnecessary build-up of stocks of crop protection products is a major concern for GCPF member companies and associations. Not only can it mean the waste of products that are disposed of without ever being used for their intended purpose, but improperly stored products can pose problems for local communities. The situation can only be improved if countries are dedicated to changing product procurement and management systems.

There are a number of good practices that can alleviate the situation, and internationally developed guidelines help governments with their management tasks.

- GCPF member companies cooperate with donors and governments to analyse the demand for crop protection products and to assist in monitoring stocks after sales.
- A training module is being developed by GCPF for Safe Use Initiative activities in Africa to raise local governments' awareness about responsible stock purchasing and management.
- Strategic stocking of locust control products normally occurs before an infestation. As no outbreak has occurred in many years, obsolete stocks have built up. GCPF member companies are willing to support the efforts of governments, donors and other stakeholders to manage these buffer stores in order to avoid the build-up of products.

Broad cooperation to eliminate obsolete stocks

Many government-owned obsolete stocks of crop protection products are left over from donations provided under various international development assistance programmes, or have accumulated in countries where procurement in planned economies was carried out centrally, without the full awareness of actual crop protection needs at farmers' level.

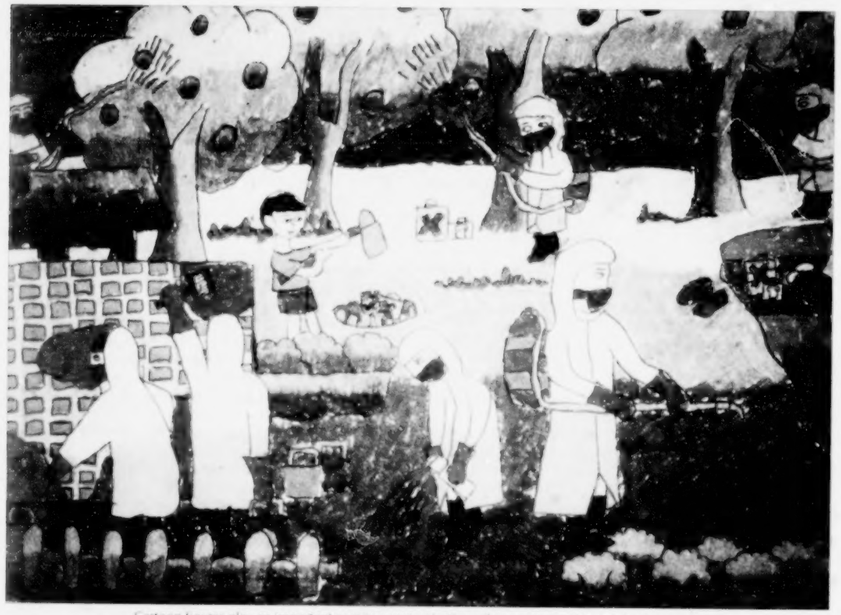
Recognizing that the developing countries involved often do not have the resources to manage these stocks alone, GCPF works with other stakeholders – donor agencies, aid organizations, exporting governments and regional bodies, as well as hazardous waste disposal companies – to provide assistance. GCPF itself offers advice and technical support where appropriate. GCPF member companies often choose to give further support to the multi-stakeholder approach if they originally supplied the stocks in question; the level of assistance is decided on a case-by-case basis by individual companies after verification of their stocks and their origin.

The stock verification process is crucial because not all of these built-up stocks are actually obsolete – some can still be repackaged, reformulated or reused, avoiding needless destruction of products that may still be useful. The verification process identifies the appropriate disposal option and gathers information to estimate costs of individual disposal operations.

Disposal projects are complex undertakings involving many areas of expertise such as project design, inventory production, stakeholder identification, fund seeking, bilateral agreements and contractor selection. At times this complexity unfortunately creates obstacles to a speedy resolution of the problem.

Case studies: how GCPF responds to the challenge of obsolete stocks

In 1998, GCPF appointed an Obsolete Stocks Coordinator to oversee the crop protection industry's involvement across the globe.



Cartoon figures play an important part in communicating safe use messages to rural communities

GCPF companies and local crop protection associations are already cooperating with various stakeholders to manage obsolete stocks in several countries. Actions are taken jointly with some combination of aid organizations, government authorities and NGOs.

This country-by-country approach has already begun to bear fruit, as obsolete stocks have either been repackaged and put back into service or safely eliminated in several countries (Brazil, Gambia and Mauritania). Other projects will soon draw to a close (including in Madagascar and South Africa).

Authorities in the state of Paraná, Brazil, accumulated some 1200 tonnes of obsolete crop protection products over the years. These were all recently incinerated locally at a GCPF member company production facility.

An initial inventory in Madagascar listed 160 tonnes of older crop protection products, but half were reusable; the other 50% are being shipped to Europe for incineration. The final report should become available in early 2000.

Almost all of the 120 tonnes of products inventoried in Malawi were reformulated and reused. An updated inventory is being carried out to identify the best disposal option for the remaining stocks.

Container management

Packaging plays a vital role in delivering crop protection products while minimizing risks of leakage in the supply chain and exposure to operators. A reduction in the amount of used packaging requiring disposal can be achieved by a shift in product presentations and/or formulation innovation. The basic requirements for quality design are that the container should drain well and allow easy and effective rinsing in order to maximise residue removal.

Container management strategies establish practices for recovery and disposal of empty, cleaned packaging. This set of practices should be appropriate to specific local circumstances, evolve in line with improvements in technology, legislation and infrastructure, and be both environmentally and economically acceptable. To this end, GCPF encourages the practice of triple-rinsing prior to recovery and/or disposal.

A prerequisite for collection and/or recovery schemes is finding a clearly defined end use for collected plastic and other packaging materials. GCPF's container management philosophy promotes alliances with other industry collection schemes and seeks the involvement of distributors, retailers, farmers and farmer associations, custom applicators, local authorities, government environmental agencies, professional waste collection companies and other stakeholders.

Where it is unlikely that alternative approaches could entirely replace on-farm disposal methods (including controlled burning and on-farm burial), farmers can consult best practice guidelines drawn up by GCPF. Not surprisingly, the longest running container collection and recovery schemes have been operational in developed countries, but developing countries are quickly adopting similar initiatives.

Case study: *drumMUSTER* – working together to protect the environment

Australia's innovative *drumMUSTER* programme is based on the collection of non-returnable rigid metal and plastic containers used in the packaging of crop protection and animal health products. Users of these products are responsible for cleaning the empty containers correctly before bringing them to their local *drumMUSTER* collection centre on designated days.

In Gunnedah, where the programme was launched, an appointment book system was created for managing the delivery of drums, saving farmers time and Gunnedah Shire Council money. Farmers phone in advance to make an appointment to deliver their drums to centres established by the Council at a mutually convenient time, thereby avoiding queues and ensuring a steady workflow for inspectors. The Council informed around 800 farmers about the programme by mailing a flyer, backed by a successful community service media campaign.

Manufacturers pay a levy per kilogram/litre to Agsafe, the safety training subsidiary of Avcare (Australia's National Association for Crop Production and Animal Health) that manages the *drumMUSTER* programme. Each container bears a special logo to show it is part of the programme. Councils then provide Agsafe with documentation on the amount of material received during their collection period and are reimbursed for the cost of collection service.

Following the successful Gunnedah launch, *drumMUSTER* has started inspector training workshops for Council employees in all other states. By October 1999, over 28 Councils had successfully undertaken collection days.

drumMUSTER was developed by Avcare in collaboration with the National Farmers Federation, the Veterinary Manufacturers and Distributors Association, the Australian Local Government Association and, on a co-regulatory basis, with the Australian Competition and Consumer Commission.

This programme, which is a model of the continual process of accountability the crop protection industry imposes on itself, demonstrates a strong commitment to the environment and sustainable agriculture. It has direct impact by improving the interaction between the retailer, distributor and purchaser while providing farmers with the knowledge to choose product containers that are environmentally friendly.

Working globally towards sustainable agriculture

The crop protection industry strives to help farmers secure their income and ensure an adequate supply of food, feed, fibre and other useful products through sustainable agriculture. This means balancing production with environmental protection and socio-economic purpose. GCPF stewardship programmes are designed to achieve this balance.

The key to GCPF's successful stewardship programmes is outreach; GCPF maintains an open dialogue with governments, NGOs and other stakeholders to implement sustainable solutions worldwide. In doing so, local communities are empowered to create their own strategies for sustainable agriculture, drawing on GCPF's contribution.

To this end, GCPF also works closely with international organizations, such as FAO, WHO, the World Bank, UNEP and the OECD.

For further information on GCPF activities, please consult the GCPF web page at http://www.gcpf.org or contact the secretariat at the above address. Tel: + 32 (2) 542.04.10; Fax: + 32 (2) 542.04.19; E-mail: gcpf@pophost.eunet.be ◆

Integrated Pest Management: UNEP and FAO partnership

Sustainable development is vital for the future well-being of our planet, and integrated pest management (IPM) exemplifies the kind of strategy needed to accomplish it. The Food and Agriculture Organization of the United Nations (FAO) and UNEP, through the Chemicals Unit (UNEP Chemicals) of the Division of Technology, Industry and Economics, are working together to make IPM more of a reality in more of the world today.

IPM is a good example of sustainable development. Through IPM, various sectors of society and partner government organizations have the opportunity to work together to design environmentally sound pest management approaches based on environmental, economic and social factors. A wider range of measures come into consideration, including agricultural practices, alternatives to vector control, and site-specific characteristics as well as cost. There are few "silver bullets" in regard to environmental issues. However, given that the level of pesticide use in most situations is above the social optimum, stakeholders working together can make IPM a win-win process.

Misuse of pesticides is harmful to human health and the environment, with high social costs. Millions of people are poisoned by pesticides every year, and pest problems are often made worse when the balance between beneficial and harmful insects is disturbed by applying toxic chemicals. The negative impact of pesticides on non-target organisms in aquatic environments, pollinators and other beneficial organisms costs millions of dollars annually.

In developing countries during the Green Revolution, pesticides were considered a necessary part of crop intensification. A number of policy instruments were applied to make purchased inputs (including subsidized pesticides) available to the farmer cheaply or even free. Pesticide use also became central to agricultural loan packages and to the message disseminated by countries' agricultural extension services (which might include advice to farmers on pesticide application schedules, products and rates). This often resulted in substantial mis- and over-use of pesticides.

During the 1970s and 1980s, it became increasingly apparent that pest resurgence and resistance caused by indiscriminate use of insecticides posed an immediate threat to the gains of the Green Revolution. At the same time, research was being conducted that demonstrated the viability of biological control of major pests, especially through conservation of indigenous natural enemies. The FAO Panel of Experts on IPM indicated, however, that gaps still existed between the science generated in research institutions and common farmer practice, conditioned by years of aggressive promotion of pesticide use.

Over the ensuing years, a number of approaches were tried to bring IPM methods to small farmers – particularly rice farmers in Asia. These approaches had mixed results. Many experts claimed the principles of IPM were too complex for small farmers to master. They maintained that centrally designed messages were still the only way to convince farmers to change their practices.

By the end of the 1980s, however, a new concept emerged in Southeast Asia. This concept held that the problem was not farmers themselves, but rather the methods used to disseminate technological packages to farm communities. These methods were technologically driven, not farmer driven. Given appropriate training methods that would empower farmers through learning, farmers could:

- master the ecological principles needed to implement IPM in their fields;
- become expert in IPM;
- apply what they had learned in order to develop new initiatives and gain greater control over the conditions which they face.

A number of national IPM programmes began to implement new approaches. After ten years of experience, they demonstrated that:

- IPM is about people. To succeed, it has to be a farmer driven process;
- IPM increases the sustainability of farming systems. It improves ecological sustainability, as it relies primarily on environmentally sound processes including the use of pest resistant varieties, the actions of natural enemies, and cultural control. It improves social stability because it is institutionalized at the level of the farming community and local government. Finally, IPM programmes are economically sustainable, as they reduce farmers' dependence on procured inputs.
- In addition to pest management issues, IPM training also addresses other factors that affect implementation of pest management strategies. These include soil and water management, gender issues, the continuation of group activities when the training phase is over, and (in one country's farmer field schools) HIV/AIDS.

Towards community IPM

The central lesson of programme implementation over the past decade has been that the complex ecological and social context of IPM argues for a sustained effort combining elements of technological development, adult education, local organization, alliance building and lobbying. Scientific excellence and adherence to ecological principles provide a strong technical basis for IPM development. The application of participatory, non-formal adult education methods represents a real advance over models based on information dissemination and the delivery of simple messages, but these in themselves are not enough. Long-term development of sustainable small-scale agriculture, which includes IPM management by farmers, also requires strong farmer groups and linkages between these groups and the wider community.

A role for UNEP Chemicals

Working together with FAO, UNEP Chemicals plays an important role in supporting IPM. It assists WHO in its dynamic development of alternatives to pesticides. It also contributes to government efforts to make informed decisions on international trade in certain hazardous chemicals and pesticides. And its information and capacity-building programmes strengthen the framework for sound management of chemicals which underpins IPM.

The evolution of IPM as a tool for agricultural pest control has meant that, logically, FAO should and does provide the leadership within the UN system for its promotion. However, UNEP and other intergovernmental organizations have taken steps to support and complement FAO's work in promoting IPM.

The activities UNEP Chemicals engages in that support IPM include working jointly with FAO as secretariat for the Rotterdam Convention on Prior Informed Consent. This treaty, adopted and signed in 1998, concerns international trade in hazardous chemicals and pesticides, focusing on those that are banned or severely restricted as well as severely hazardous pesticide formulations. Its implementation will lead many countries towards identifying and implementing less dangerous alternatives to certain pesticides and practices. It provides an opportunity for increased use of IPM.

UNEP Chemicals is also leading global efforts to reduce and/or eliminate releases of persistent organic pollutants (POPs) to the environment. Its main function is to provide the secretariat for POPs negotiations, which are scheduled to complete development of a treaty by the end of 2000. However, UNEP also promotes immediate actions on POPs in a number of areas. One of these is helping countries identify, and shift to, alternatives to continued use of pesticides that are POPs. UNEP is implementing a world-wide training programme, jointly with FAO and WHO, to help promote the shift away from continued POPs use. Training includes an emphasis on implementing IPM and IVM (integrated vector management) strategies.

UNEP Chemicals also supports implementation of the Code of Ethics in the International Trade of Chemicals. The Code of Ethics is a voluntary industry initiative to help promote the safe trade and use of chemicals throughout their life-cycle. Developed in 1994, it is being applied by industry in developed and developing countries. It aims to ensure that industry voluntarily acts to ensure: the addressing and reduction of testing and assessment of hazards and risks to people and the environment; classification, packaging and labelling of chemicals; provision of information to customers and end-users; education and training of customers and end-users; and monitoring and follow-up of improvements in chemical safety. This type of product stewardship should lead to shifts away from especially dangerous products towards more benign practices. It should ultimately help farmers and others apply safer and more effective technologies.

International chemical safety activities are undertaken within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC), which allows the formulation of broader and stronger partnerships throughout the entire community of intergovernmental organizations (IGOs). The IOMC currently includes UNEP, FAO, WHO, UNIDO, ILO, UNITAR and OECD.

Close and continuing co-operation among FAO, UNEP Chemicals and other partner organizations ensures that IPM will reach more agricultural communities throughout the world, bringing us all closer to the goal of sustainable development.

For more information, contact: Jim Willis, Director, UNEP Chemicals, 11-13 Chemin des Anémones, CH-1219 Châtelaine, Geneva 10, Switzerland; Tel: + 41 (22) 917 81 11; Fax: + 41 (22) 797 34 60; http://www.communityipm.org; http://www.chem.unep.ch/pops/; http://www.pic.int. Also: Gero Vaagt, Plant Protection Service, FAO, Viale delle Terme de Caracalla, I-00100 Rome, Italy. E-mail: Gero.Vaagt@fao.org; http://www.fao.org/waicent/faoinfo/agricult/agp/agpp/ipm/Default.htm.

Supplying plant nutrients for sustainable agriculture – life-cycle approaches in the fertilizer industry

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Abstract

The search for sustainable agricultural systems places a requirement on all agri-food industries to seek the most efficient form of production in terms of energy; raw materials, manufacture, waste, distribution and consumption, while satisfying consumers' food security and quality demands. Environmental and socio-economic performance must be evaluated over the entire life-cycle of the food chain, which (in the case of mineral fertilizers) includes extraction and processing of raw materials, manufacturing, distribution, agricultural use, and the destination of nutrients beyond the farm gate in food and industrial products. Recycling and losses from the system must all be considered.

Résumé

La recherche de systèmes agricoles écologiquement viables oblige l'ensemble des branches de l'industrie agroalimentaire à chercher le mode de production le plus efficace du point de vue de l'énergie, des matières premières, de la fabrication, des déchets, de la distribution et de la consommation, tout en répondant aux demandes du consommateur en termes de sécurité et de qualité des produits alimentaires. Les performances environnementales et socio-économiques doivent être évaluées sur la totalité du cycle de vie de la chaîne alimentaire, autrement dit doivent inclure (dans le cas des engrais minéraux) l'extraction et le traitement des matières premières, la fabrication, la distribution, l'utilisation par les agriculteurs et la destination des éléments nutritifs au-delà de l'exploitation agricole, dans les produits alimentaires et industriels. Le recyclage et les pertes dues au système ne doivent pas être oubliés non plus.

Resumen

La prospección de sistemas agrícolas sostenibles impone a todas las industrias agroalimentarias el compromiso de estudiar el modo de producción más eficiente en lo relativo a la energía, las materias en bruto, la elaboración, el tratamiento de desechos, la distribución y el consumo, al tiempo que garantizan las demandas del consumidor en cuanto a la seguridad y la calidad. Los avances medioambientales y socioeconómicos deben evaluarse a lo largo de todo el ciclo vital de la cadena alimentaria. Esto incluye asimismo (en el caso de los fertilizantes minerales) la extracción y el procesamiento de las materias en crudo, la elaboración, la distribución, el uso agrícola y el destino de los nutrientes reservados para productos alimentarios e industriales una vez que salen del campo. También han de tomarse en consideración el reciclaje y las pérdidas del sistema.

Introduction: essential plant nutrients

All forms of life need energy, food and water, and plants are no exception. Plants convert nutrients, air, water and energy from the sun into biological products, some of which are used directly for human food, others to feed animals or supply natural fibres or industrial and construction goods.

Three plant nutrients are required in large quantities – nitrogen, phosphorus and potassium. Sulphur, calcium and magnesium also are required in substantial amounts. These nutrients are constituents of many plant components such as proteins, nucleic acids and chlorophyll, and are essential for processes such as energy transfer, maintenance of internal pressure and enzyme action. Seven other elements are required in small quantities and are often referred to as "micronutrients" or "trace elements".

Rainfall supplies water and part of the oxygen. The atmosphere supplies carbon (as CO_2) and the rest of the oxygen. Legumes and certain other plants can obtain part of their nitrogen from the atmosphere, but most plants obtain almost all their nitrogen from the soil. All other plant nutrients must be obtained entirely from the soil – or from what is added to the soil by animals and man.

How important are fertilizers?

Due to the number of factors involved, it is inherently difficult to quantify the share of nutrients supplied as mineral fertilizers[1] in increasing agricultural output, but they are estimated to contribute about 40% of the nitrogen taken up by the world's crops. Since crops provide about 75% of all nitrogen in human protein consumption (either directly, or indirectly through animals), it follows that nearly one-third of this protein depends on fertilizers.

In Western Europe, it is thought that roughly half the present agricultural output can be attributed to fertilizers. Livestock wastes account for 30% of the nitrogen, 48% of the phosphate and 63% of the potash applied to crops, much of it coming from intensive livestock production units. Non-livestock wastes account for only 3% of the nitrogen, 4% of the phosphate and 1% of the potash. Hence fertilizer accounts for 67% of the nitrogen, 48% of the phosphate and 36% of the potash.

It must also be remembered that much of the nutrients contained in livestock wastes in Western Europe are derived from animal feeds imported from countries such as Brazil, Argentina, Thailand, Canada and the United States. These feed grains are harvested from crops supplied with nutrients in the form of fertilizers which often originate as mineral deposits in other countries in North Africa, North America, Asia, the former Soviet Union and elsewhere.

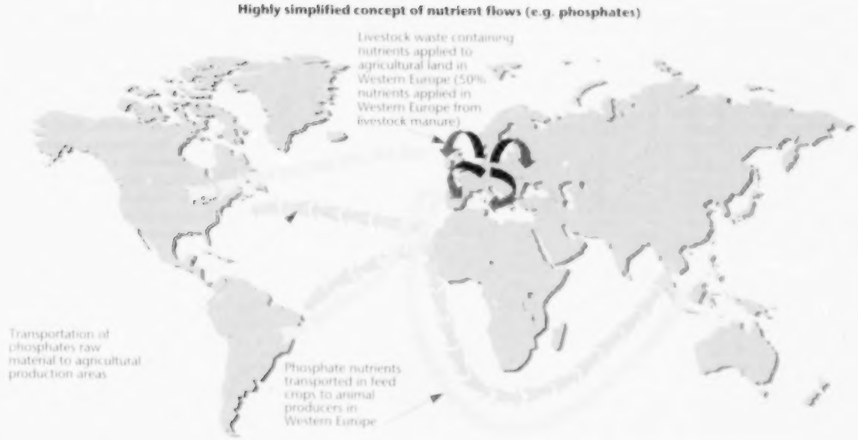
The "life-cycle" of fertilizers must be considered both vertically (the passage of nutrients through the food chain from fertilizer, to soil, to crop, and on to the final food and the eventual destination of waste products), but also horizontally (the transportation of nutrients, often great distances, from their source to the land where they are applied and on to the final consumer). The anthropogenic "life-cycle" of plant nutrients is therefore inextricably linked to the natural nitrogen and carbon cycles and the increasing food and fibre demands of a growing world population.

Consequently, world production of raw materials, intermediates and finished fertilizer products has grown from virtually zero in the mid-19th century to a current total of about 500 million tonnes, of which about 200 million tonnes is transported internationally. World fertilizer consumption, on a nutrient basis, is around 135 million tonnes. It is no coincidence that this expansion has occurred in proportion to the increase in global crop production and population.

Does recycling organic material achieve sustainability?

A common misinterpretation of the concept of sustainability in the context of plant nutrition is that farmers should be able to operate within a closed cycle, whereby nutrients extracted from the soil are passed through the food chain and then returned to the soil allegedly without the need for external inputs. However, losses are inevitable as crops are harvested and exported from the farm.

Highly simplified concept of nutrient flows (e.g. phosphates)


Livestock waste containing nutrients applied to agricultural land in Western Europe (50% nutrients applied in Western Europe from livestock manure)
Transportation of phosphates raw material to agricultural production areas
Phosphate nutrients transported in feed crops to animal producers in Western Europe

The recycling of available organic material (plant and animal residues) is recommended as a major contribution to soil organic matter content, helping to retain moisture and build soil structure, but it should be recognized that recycling is alone of insufficient nutrient value for sustainable, productive cropping.

Manure and slurry have a low plant nutrient content compared with mineral fertilizers. They are expensive to transport and difficult to handle and spread. Losses to groundwater and the atmosphere can be substantial, and they are very variable in quality depending on the animal, type of feed, storage conditions, etc. A large proportion of the nitrogen contained in manures is initially insoluble. It is released when the organic matter is broken down, which can take several seasons. In most developed countries, the disposal of animal wastes and human sewage sludges is increasingly controlled by legislation.

The share of livestock wastes as plant nutrients in Western Europe is given above. In the USA it is estimated that in 1992, of total available plant nutrients, animal wastes accounted for 10% of the nitrogen, 24% of the phosphate and 22% of the potash. However, because of transportation costs, use of animal wastes as fertilizer is economically feasible only if on-farm or nearby sources exist, and this occurs over a very limited area. The areas with a surplus of manure probably account for less than 1% of the world's arable area.

In addition to the losses in food crops and animal feed, biomass is also used for energy and building materials and nutrients are lost in natural processes to the atmosphere, through soil erosion, and dispersed deeper in the soil or locked up in inaccessible complex particles. Indeed, in many societies farm animal waste is more valuable as a fuel energy source than as a nutrient source, due to its high carbon content and low value for nitrogen, potassium or phosphorus.

Is "traditional" agriculture sustainable?

Historically, agricultural systems were maintained with various techniques of shifting cultivation feeding a limited population. Techniques of fallow rotations with legumes were practised in Europe as early as Roman times. These were gradually replaced by mixed farming with animals and crops. As population pressure increases, shifting cultivation systems collapse because the soil cannot recover naturally as fallow periods are reduced.

In China, as in much of Asia, the diet was traditionally based on pigmeat, vegetables and irrigated rice. Farmers practised excellent management of the cultivated land, recycling nutrients and relying on replenishment in irrigation sediments, which maintained rice yields at around 700 kg/hectare for thousands of years. As late as 1949, organic sources provided more than 98% of the nutrients applied to soil. As a result of population pressure, greater affluence and changing dietary patterns (notably increased levels of meat consumption), the proportion is now less than 38%. China has become the world's largest fertilizer consumer, accounting for over 20% of total supply. In the same period, yields have multiplied six-fold to reach, on average, 5958 kg/hectare. As each inhabitant of China consumes an additional kilo of meat per year, cereal production must rise by 10 million tonnes.

If India had to produce its current wheat volume with the technology of 25 years ago, an additional 40 million hectares would be required. As the supply of farmland is limited, it is largely existing cultivated land which must support a maximum expected world-wide population increase of six to nine billion through a near doubling of food production per hectare.

In Sub-Saharan Africa, the current net nutrient loss from the soil is estimated at some 10 million metric tonnes per year. Even today's low yielding crops are extracting nutrients from the soil three or four times faster than they are being replaced.

The International Food Policy Research Institute (IFPRI) has projected a global increase in cereals demand of 41% between 1993 and 2020. Similarly, it forecasts a 63% rise in meat demand and a 40% rise in demand for roots and tubers. The developing countries will account for 80-90% of these increases, with Sub-Saharan Africa experiencing the largest demand increases (100-150%). More than 90% of this additional food is forecast to come from higher crop yields, though higher agricultural prices would provide some incentive to make the high capital investments needed to develop new agricultural land. However, much of the existing farmland also needs massive infrastructural investments to bring it within reach of modern agriculture, and increasing food prices in poor developing countries is politically unattractive.

Food production and energy

It is estimated that world agriculture uses about 5% of global energy consumption. This excludes transport and processing of the agricultural produce, which is more energy intensive. The entire food sector generally accounts for 10-17% of total energy now used in industrialized countries.

For 1 kg of bread, growing the wheat takes about 20% of the energy used, while milling, baking and distribution account for 80%. Thanks to photosynthesis, in the case of cereals and root crops the harvested energy is substantially greater than the energy input. In the case of intensive horticulture, the energy input may be higher than the energy output.

Fertilizer production and energy

Fertilizers, especially nitrogen fertilizers, require fossil fuel energy to manufacture, and some to transport and apply. Energy consumption has become an environmental issue because of the cor-

The agri-food industry

logical impact of energy production and transport, and because greenhouse gases are emitted from fuel burning.

Fertilizer production currently accounts for about 2-3% of total global energy consumption. For Western Europe, the corresponding figure is about 1%. Nitrogen fertilizers account for a large majority of this consumption. Most of the energy for fertilizer production is required by the fixation of atmospheric nitrogen to manufacture ammonia. Energy is also required for the conversion of ammonia to liquid urea melt. For the manufacture of ammonium nitrate, the conversion of ammonia to nitric acid provides a net energy gain which can be used, for example, to produce electrical energy in a steam turbine. The neutralization of ammonia with nitric acid to produce ammonium nitrate, also releases energy. In the case of phosphate fertilizers, energy is required for the mining of the ore, the production of phosphoric acid, further processing into finished products, and pollution control.

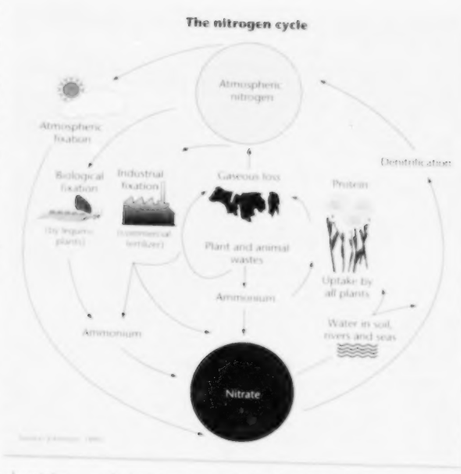
Although fertilizer production will always consume large amounts of energy in processes requiring high temperatures and pressures, the industry has become more energy efficient through improved design. Ammonia factories built in 1990 used some 30% less energy per tonne of nitrogen than those designed around 1970. Present design is thermally very efficient, and further energy saving beyond another 5-10% is not feasible in ammonia production. Other potential nitrogen fixing methods (e.g. high temperature oxidation) are much less energy efficient. In the case of urea, improved efficiencies achieved by modern total recycle plants have halved the total energy input in the last 30 years.

The high-temperature catalytic synthesis of ammonia from air and a source of hydrocarbons is by far the main consumer of energy in the fertilizer industry, and natural gas is the preferred feedstock. The accelerating dependency on natural gas is a cause for long-term concern. However, large economic and environmental costs mitigate against other, more polluting fossil hydrocarbons (mainly coal). Hydroelectric power can also be used, though this would require higher energy consumption and major relocation of factories.

Natural gas is expected to account for about one-third of global energy use in 2020, compared with only one-fifth in the mid-1990s. The ammonia industry used about 5% of natural gas consumption in the mid-1990s – a figure which is expected to diminish substantially in coming years.

Energy efficiency in agriculture

In his book *Feeding the Ten Billion*, Lloyd Evans describes the classical analysis of changing energy use in agriculture carried out by David Pimentel on maize (corn) production in the USA from 1945 to 1985. As usual in such studies, solar energy intercepted by the crop is not included as a component of on-farm energy use as it is more than 99% of the total. On the output side, the energy analyses stop at the farm gate, but go upstream enough to include the energy "embodied" in the manufacture and transport of machinery, fertilizers, etc.



Evans plots the output energy against the input energy to find that, overall, the maize crops have continued to return at least three more joules in additional grain for each additional joule invested in the crop, and substantially more than that from 1975 to 1985. Only between 1964 and 1970 did there appear to be a sign of diminishing returns. However, when Vaclav Smil reanalysed the Pimental data and allowed for improvements in fertilizer manufacture and other changes, this apparent decline in efficiency disappeared.

Clearly, improvements in efficiency off-farm have helped to maintain the efficiency of energy use for maize production, but so have improvements on-farm. For example, despite the four-fold increase in yield between 1945 and 1985, the use of liquid fuels per hectare decreased by 11% thanks to improvements in cultivation and weed control. The most pronounced change in energy input terms has been for nitrogenous fertilizers, which rose from 6.7% of the total in 1945 to 31% in 1985. The second largest energy-using component in 1985 was irrigation (22%), up from 5% in 1945. Other marked increases have been for herbicides and grain drying.

Instead of comparisons across time in one region, Flinn and Duff compared the energy budgets of rice crops grown under 21 different conditions, mainly in Asia but ranging from traditional and low input to extremely intensive, both organic and conventional. Their results indicate the absence of diminishing returns to increasing energy input. Likewise in France, Sylvie Bonny has found no decline in the efficiency of energy use for wheat growing in the Paris basin between 1955-60 and 1990.

Of course, there are innumerable examples of diminishing returns related to any one factor, e.g. nitrogenous fertilizer. Detailed energy analysis, however, evaluates many inputs and outputs in modern agriculture with a common base: energy consumed and energy produced. Evans contends this has shown us, unambiguously, that at least for rice, wheat and maize, the three main staple crops of the world, yields per hectare can be increased many-fold without diminishing returns to non-solar energy consumption setting in.

Results from a recent study by Martin Luther University at Halle-Wittenburg in Germany, commissioned by the European Fertilizer Manufacturers Association, show that, averaging all investigated cropping systems, the energy output exceeded the input of fossil energy by a factor of 4.0-19.8, or the mean value of 10.2. The expenditure of nitrogenous fertilizer that furnished the highest energy gain was nearly identical with the nitrogen amount for the maximum yield.

Fertilizer composition

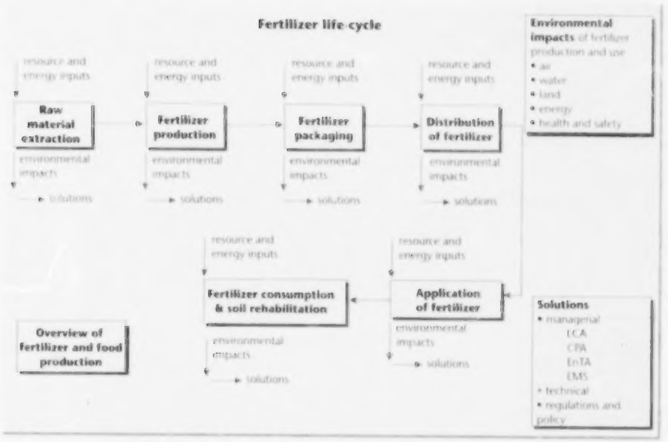
The consumption pattern of the different fertilizer products has gradually changed. Since 1973-74, most of the increase in world nitrogen consumption is accounted for by urea, most of the phosphate by diammonium phosphate, and most of the potash by potassium chloride. It is significant that these, as well as compound fertilizers, are products with a high nutrient concentration. They offer considerable savings in storage, transport, handling and application costs, compared with otherwise excellent but low-analysis fertilizers – at least in terms of the three major nutrients.

A simple calculation demonstrates that an increase in nutrient concentration from 30% to 40% results in a 25% reduction in transport and handling costs, an increase from 40% to 50% in concentration leads to a further 20% reduction, and these costs can account for up to half the farm-delivered cost of a fertilizer.

For the same reason, i.e. their higher nutrient concentration, urea, ammonium phosphates and potassium chloride dominate world fertilizer trade. China and India are particularly large importers of ammonium phosphates and potash, and fluctuations in the import requirements of these countries have a major impact on world prices.

Fertilizer use efficiency

The proportions of fertilizer nutrients taken up by the crop during the season of application are: nitrogen 50–70%; phosphate 10-25%; potash 50-60%. In practice, particularly in developing countries, losses can be much greater. Nitrogen loss



ranging 20% from conventional nitrogenous fertilizers is unavoidable (the plant is in competition with the soil microbial population, especially in soils where organic matter is accumulating), but under unfavourable circumstances losses of 70% and more have been reported.

In view of the large quantities involved, inefficiencies in fertilizer use represent not only an environmental hazard but also a substantial economic loss. Given that about 80 Mt of nitrogen were used in world agriculture in 1996, a 20% loss with a wholesale price of US$ 0.66 per kg of nitrogen in urea amounts to US$ 10.6 billion.

Limited improvements in fertilizer use efficiency can be detected in most agriculturally advanced regions, but this can be attributed mainly to improvements in cultivation practices, techniques of fertilizer application and crop varieties. Promising results are being demonstrated in the emerging field of "site-specific" or so-called "precision" farming, whereby new technologies and farm management practices are integrated to achieve balanced nutrition, maximize nutrient recycling and reduce losses.

The experience in the United States and Europe shows how this precision technology may influence the fundamental structure of the industry – perhaps in time changing it from a basic commodity, raw material supplier into a value-added service provider, offering farmers a fully integrated system in which the fertilizer is merely an ingredient but the delivery mechanism is the profit centre.

Atmospheric nutrient losses

Atmospheric pollution is high on the global agenda, particularly through the UN Framework Convention on Climate Change. The fertilizer industry has responded well to the challenge of improving the efficiency of fertilizer *production* (particularly energy consumption), especially in Europe and North America. Greenhouse gas emissions have been reduced in some cases to near zero. Although improvements in the efficiency of fertilizer *use* can also be detected in most agriculturally advanced regions, this can often be attributed to improvements in cultivation practices, application techniques and crop varieties. In future, greater attention must be paid to atmospheric emissions from applied fertilizer and the agro-ecological system. Experiments demonstrate that nitrogen compounds lost to the atmosphere following the application of urea can amount to 20% or more under temperate conditions. Losses are even higher, 30–40% and more, under tropical conditions on flooded rice and on crops which do not involve tilling of the soil such as bananas, sugar cane, oil palm and rubber. Under certain circumstances, the loss can be in the form of nitrous oxide (N_2O), which has a global warming potential 300 times greater than that of CO_2.

This environmental challenge may ultimately drive the search for a fundamentally different mechanism to supply crop nutrients, perhaps via some combination of biological and chemical processes.

Fertilizer product improvement

Slow- and controlled-release fertilizers, nitrification and urecase inhibitors can considerably reduce nitrogen losses to water and to the atmosphere, at the same time significantly improving fertilizer efficiency. Some companies in the industry are leading the development of a range of "speciality" fertilizers, including specially tailored formulations for specific applications and crops.

However, despite these product developments, there has been little significant change in the fundamental nature of the main fertilizer products for decades. The financial resources devoted to product research have been steadily declining over many years. There is little incentive to invest in the research and development of a bulky, low-priced commodity which offers little scope for product differentiation.

The industry must therefore increasingly improve the *efficiency* of the nutrient supply chain – from fertilizer production to crop production and beyond. This should become the guiding force in the development of the industry, to satisfy the demands of world food security and achieve economic, social and environmental sustainability.

Conclusion

Despite the energy and resources used in their manufacture, and the considerable margin for improvement in their use, it is widely acknowledged that there is currently no effective substitute for mineral fertilizers, which play a vital role in supplying about half the nutrients required by agricultural crops to feed the current global population of over six billion.

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Mineral Fertilizer Use and the Environment. IFA/UNEP, 1998, 46pp.

Notes

1. International Fertilizer Industry Association (IFA). Tel: +33 (1) 53.93.05.00, Fax: +33 (1) 53.93.05.45, also 05.06 or 07, E-mail: ifa@fertilizer.org, Internet: *www.fertilizer.org*

2. In this article the term "mineral" is used in preference to "chemical", "artificial" or "synthetic" fertilizers. Apart from nitrogenous fertilizers, they are more or less purified minerals. In the case of nitrogen, approximately 99% of the total supply is produced from ammonia, which is manufactured from the abundant atmospheric nitrogen reacted with hydrogen.

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Global fish consumption

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Abstract

Despite continuing scientific uncertainty, evidence that current fishing practices are unsustainable is mounting. Warnings about overfishing and the potential threat to food security among the poor are being taken increasingly seriously at the national and international levels. Recent years have seen a flurry of agreements to improve fisheries management. However, there is strong resistance to downsizing the world's fishing fleets both in rich countries, where local communities and traditions may be at stake, and in poorer ones where fish are also of fundamental importance for food supply and fishing is one of few sources of livelihood in coastal regions.

Résumé

Malgré des incertitudes persistantes chez les scientifiques, il est de plus en plus évident que les pratiques halieutiques actuelles ne sont écologiquement pas viables. Les mises en garde concernant la surexploitation des stocks de poissons et la menace potentielle qui pèse sur la sécurité alimentaire des pays pauvres sont de plus en plus prises au sérieux à l'échelle nationale et internationale. Ces dernières années, on a vu se multiplier les accords pour améliorer la gestion des pêcheries. Mais la réduction de la taille des flottes de pêche se heurte à de fortes résistances, tant dans les pays riches où ce sont les populations et les traditions locales qui sont en jeu, que dans les pays pauvres où le poisson est l'une des bases de l'alimentation et où la pêche est l'un des rares moyens d'existence dans les régions côtières.

Resumen

A pesar de la persistente incertidumbre científica, cada vez es más evidente que las prácticas de pesca actuales no son sostenibles. Los avisos sobre la pesca excesiva y la amenaza potencial que supone para la seguridad alimentaria entre los más pobres están adquiriendo cada vez más importancia tanto a escala nacional como internacional. En los últimos años se han redactado multitud de acuerdos para mejorar la gestión de esta actividad. Sin embargo, la resistencia a reducir las flotas pesqueras se acrecienta tanto en los países ricos, donde están en juego la tradición y las comunidades locales, como en los menos favorecidos, para los que la pesca es una parte fundamental de los recursos alimentarios y uno de los pocos medios de subsistencia de las regiones costeras.

Fish in the human diet

Fish and shellfish are a more important element in the human food supply than many people realize. Globally, fish account for about 16% of animal protein consumed. In some Asian countries, the proportion rises to between 30 and 50%. About one billion people world-wide, the great majority of them in developing countries, rely on fish for their primary source of protein. The world's annual fish harvest by weight exceeds production of any one of the four main animal commodity groups (beef and veal, sheepmeat, pigmeat and poultry). In developing countries, fish production is not far behind the total production of all four animal commodities put together.

Fish also contribute indirectly to the human diet. About 25% of the annual fish harvest is converted into fish meal and fish oils, which are used as a component of livestock and poultry feeds. Fish meal is also used to feed fish. Today, as fish and shellfish are increasingly raised in fish farms, rather than caught from the sea or inland waters, a small but measurable share of the fish harvest is diverted to produce more valuable species like salmon and shrimp. This trend has potential implications for food supply in some Asian countries, where most fish food is produced.[1]

Production and consumption patterns

In 1996, global fisheries production totalled 121 million tonnes, of which some 72% came from marine fisheries, 6% from inland fisheries, and the remaining 22% from aquaculture (including edible aquatic plants). World fishing activity is highly concentrated, with just 20 countries accounting for about 80% of production and ten countries for almost 70% (**Figure 1**). Global production today is dominated by the developing countries, a major change from the 1950s when about 80% of the world's fish catch was taken by the developed countries. The shift has been brought about by the establishment of Exclusive Economic Zones (EEZs) during the 1970s and 1980s, which granted coastal countries exclusive rights to use and develop fisheries with a 200 nautical mile boundary, and by the rapid growth of aquaculture in Asia and Latin America.

Aquaculture has grown at an average annual rate of over 10% since 1984, with growth still accelerating. Asia accounts for over 75% of world output. China dominates production with its huge areas of inland carp ponds. Southeast Asian countries, notably Thailand, Indonesia and Vietnam, and some Latin American countries have rapidly expanded their output of higher-value fish and crustaceans.

Fish consumption shows a somewhat different global distribution. In bulk terms, the developing countries again account for the majority share, but their much larger populations mean that average consumption per person in some regions is very much lower than in the developed world. **Table 1** shows the leading consumer countries or regions, and their average consumption per capita.

International trade in fish and fishery products

International trade in fish and fishery products was valued at US$ 52.5 billion in 1996, equivalent to 11% of total agricultural exports. In volume terms, exports reached 22 million tonnes which, when reconverted from fish product to live weight equivalent, represents about 40% of total fisheries production. Export volumes have risen three-fold since 1976, with growth driven by both the expanding world economy and the increasing availability of species in high demand, thanks mainly to aquaculture production. In value terms, more than half of fishery exports originate in developing countries, which have dramatically increased their production of more valuable finfish, and of shellfish raised specifically for foreign markets. Shrimp are now the leading aquaculture product traded internationally, and over 99% of production is in developing countries.

Today industrialized countries account for more than 80% of fish and fish product imports. This is partly the result of the establishment of EEZs, which limited the operations of industrial country distant water fleets in developing country fisheries. Japan, for example, though still a major producer in its own right, accounts for about 30% of world fish imports in order to support its consumption. In per capita terms, Japan has the highest fish consumption in the industrialized world and is exceeded only by a few developing countries such as the Maldives.

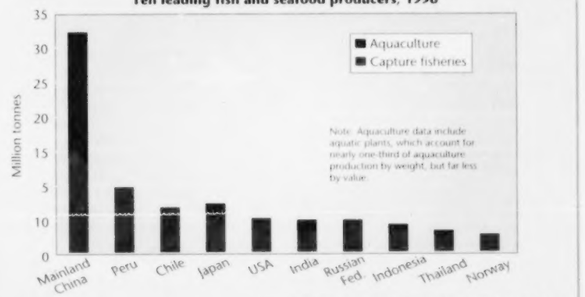
Despite the importance of international trade, more than half the total fish harvest is still consumed domestically, after being landed primarily by small and medium-scale fishers. Subsistence and local markets therefore remain of key importance to the food security of coastal and inland populations in low-income countries.

Are global fish supplies secure?

Fish production has risen steadily over the past few decades, more than keeping pace with a growing world population. Since 1950, production has increased by more than 600%, with none of the erratic fluctuations characteristic of many other food commodities. However, fisheries experts have been warning for many years that catch rates were exceeding the Maximum Sustainable Yield (MSY) of the sea. Overfishing has been formally recognized as a problem since the beginning of the century and was the subject of an international conference as early as 1947. Yet scientific warnings have frequently met with political and industry resistance to the idea that the ocean's bounty might be exhaustible. Sceptics are encouraged by the fact that MSY, while easy to grasp as a concept, is almost impossible to quantify with precision and confidence.

The security of fish supplies in the next five decades, when the world's population is expected to rise to nearly 9 billion, will be of critical importance to developing countries, where virtually all the population increase will occur. Given scientific uncertainties over maximum sustainable yields, what is the evidence that overfishing is a reality, that marine fisheries are at or near their production peak, and that continued exploitation at present rates could lead to sudden collapse? And if overfishing is a reality, what are the prospects for making up the shortfall with increased production from aquaculture and inland fisheries? The following sections address these questions by examining some key indicators: the rate of increase in fish catch; the catch to fishing effort ratio; and the degree of exploitation of various global fisheries. A more fundamental indicator, though harder to quantify, is the condition of marine ecosystems which support fish at every stage of their life cycle.

Figure 1
Ten leading fish and seafood producers, 1996



Source: FAO, The State of World Fisheries and Aquaculture 1998 (FAO, Rome, 1999)

Rate of increase in the global fish harvest

Production from the world's capture fisheries (inland and marine) has increased by an average of more than 2% per year since 1950. A closer examination of the data reveals that the rate of increase slowed from an average of 6% per year in the 1950s and 1960s to an average of 1.5% between 1983 and 1993, and to just 0.6% per year for the period 1995-96. This slowdown has been offset by rising output from aquaculture (**Figure 2**). Since capture fishery and aquaculture production are usually reported together, the popular impression remains that overall production is rising at a reassuring rate.

Catch to fishing effort ratio

The simplest measure of fishing effort is the gross tonnage of boats in the world's fishing fleet, which rose 91% between 1970 and 1992. In fact, this measure reflects only nominal capacity growth in the global fishing fleet. Technological improvements, including electronic navigation systems, sonar location devices and advanced fishing gear, have greatly improved the catching capacity on many vessels. Productivity increases are difficult to estimate for the global fleet, but a recent study of six fishery fleets in OECD countries indicates technical capacity increases of between 2.8 and 6% per year over different time periods between the 1960s and 1990s.[2] Such equipment is known to be commonly found in non-OECD country vessels, too. These dual increases in gross tonnage and technical capacity were not reflected in the 30% increase in global fish catch between 1970 and 1992 – equivalent to an average growth rate of under 1.4%.

Exploitation levels of global fisheries

A comprehensive study by the FAO Fisheries Department reviewed fish landings between 1950 and 1994 from the world's top 200 fisheries, which together account for nearly 80% of marine fish production.[3] The study reveals a clear "boom and bust" cycle in which different fisheries were successively developed and then, after harvests peaked, declined with continued fishing. Harvests from the first fisheries to be heavily exploited – the Northwest and Northeast Atlantic – peaked as early as 1968 and 1976, respectively, and have declined ever since. Harvests in the Northeast Pacific peaked in 1987, those in the Mediterranean-Black Sea in 1988, and those in the Southwest Pacific in 1992. The declines in catch have been quite dramatic: harvests of all fish stocks worldwide that the FAO classified as overexploited fell from 14 million tonnes in 1985 to 8 million tonnes in 1994, a drop of 40% in just nine years. Even this figure masks more precipitous declines in some of the most valued fish stocks, such as the Atlantic cod, haddock and redfish (**Figure 3**).

Table 1
Top fish and seafood consumers

Country or region	Total consumption (million tonnes)	Average consumption (kg/cap/year)
Mainland China	22.7	24.8
East and Southeast Asia	13.7	25.4
Japan	8.7	70.8
European Union (15)	8.6	23.8
US and Canada	6.5	20.8
South Asia	5.7	5.0
Africa	4.5	7.1
South America	3.0	10.0
Russian Federation	2.1	18.9

Note: Total consumption data are an average of 1993-95 consumption; per capita data are for 1996.

Source: FAO on-line database

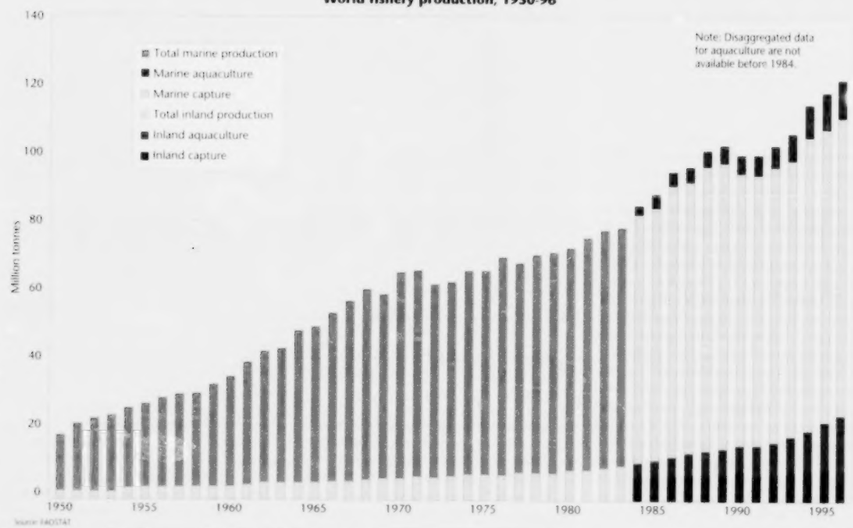
Overall, the study shows that 35% of the world's major fisheries now have declining yields and that another 25% are fully developed, with no increase occurring in yields. About 40% still have potential for increasing yields, mostly the southern fisheries of the Indian Ocean and some areas of the Pacific. Over-exploitation of these areas would have severe consequences for local fleet captures and food security in parts of South Asia and Latin America.

Condition of the marine ecosystem

The environmental damage which accompanies modern fishery practices such as deep-sea trawling is now well documented. However, the ocean strikes most people as so vast that even quite severe damage should be of limited impact. This is not the case. Most productive fisheries (in terms of their harvestable primary production) occur within a narrow band, often less than 30 metres in depth, which rings the world's coastlines and coral reef systems. A few other important areas are scattered about in areas of cold water upwelling where fish feed or migrate. Fishing fleets concentrate their operations in these relatively limited areas: about 90% of the annual marine fish harvest is caught in coastal zones (within the EEZs) and around coral reefs. Degradation of marine habitat takes many forms, and only a few can be mentioned here.

The use of bottom trawling and other mobile fishing gear is highly destructive of benthic (sea bed) communities including sponges, tube worms, urchins and anemones, which provide essential shelter and nourishment to young fish. Modern trawl nets and dredges, fitted with rollers or "rockhoppers" and weighing many tonnes, can be dragged across the sea bed at depths of up to 1200 metres. Recovery after trawling disturbance can take decades, as species recruitment and growth to maturity are slow. Heavily exploited trawl areas, however, may be trawled several times a year. New research undertaken for the World Resources Institute has compiled data on trawling grounds

Figure 2
World fishery production, 1950-96



in 20 countries from all continents except South America.[4] These countries include about 40% of the world's continental shelves. The total trawled area is estimated at more than 800,000 square kilometres, of which about 60% is located on continental shelves and the remainder in deeper waters. This figure represents about 57% of the total continental shelf area of these countries. Trawled areas may actually be much larger, due to illegal fishing activity. Many researchers believe that habitat destruction by trawling is one of the principal factors in fish declines in heavily trawled areas such as the Georges Bank off New England.

Trawling is also responsible for very high levels of bycatch, or unwanted fish caught in nets alongside the target species. Globally, much of the bycatch is discarded because the fish are too small to be commercially valuable, or because they are subject to legal constraints. In 1994, the level of bycatch and discards in the world's commercial marine fisheries was estimated at 27 million tonnes, equivalent to one-third of the total food fish catch.[5] (This figure excludes non-fish bycatch such as marine mammals and birds.[6]) Due to the very fine mesh nets used in marine shrimp fishing, these fisheries have by far the highest bycatch and discard rates, accounting for about one-third of total discards. Discarding small, juvenile fish is not only wasteful, it appears to have measurable impacts on future breeding stocks. Overfishing of mature individuals, together with high mortality of discarded juveniles, has caused the average age and size of fish harvested to decline markedly. As just one example, the average size of swordfish caught has shrunk from 120 kg to 30 kg over the past 20 years, and the breeding population has been reduced by half.

Perhaps surprisingly, small-scale fishing can be as destructive as industrial fleets, especially to coral reefs. Dynamite is increasingly used by local fishers as a quick and effective means to harvest fish from labyrinthine coral systems. Incidents of blast fishing have been reported with increasing frequency throughout Southeast Asia and parts of the Caribbean. Dynamite blasting does irreparable damage to fragile coraline structures, the rich habitats which support thousands of locally-consumed food fish species. Another threat is the practice of fishing with sodium cyanide on the reefs of Southeast Asia. Cyanide is used to stun and capture fish live, either for sale as ornamental aquarium fish or to supply the Chinese restaurant market for large, live reef fish, available for selection by patrons. Choosing to eat rare and expensive species has become a status symbol to wealthy consumers in Hong Kong and other Asian and North American cities with large Chinese populations. Once confined to the Philippines (which is now taking action against the problem), cyanide fishing has spread throughout Indonesia and into Papua New Guinea, Vietnam, the Maldives and Fiji. Cyanide is highly toxic to many non-target fish, and kills corals. Systematic data are lacking, but there is widespread anecdotal evidence of the physical and chemical damage caused by poison-fishing.

Future scenarios of supply and demand for fish

In *The State of World Fisheries and Aquaculture 1996*, the FAO estimated that, under current fisheries management regimes, the potential world-wide harvest from marine capture fisheries is no more than 90 million tonnes, and that this could not be sustained for long. Under much improved management, where depleted stocks are allowed to recover and other stocks are wisely used, this figure might rise to a total of 105 million tonnes. The FAO's conclusions are broadly confirmed by other fisheries experts including the International Food Policy Research Institute (IFPRI) and the International Center for Living Aquatic Resources Management (ICLARM). The supply from aquaculture continues to grow and, according to the FAO's 1998 report, the sector could increase production from its current level of 27 million tonnes to between 35 and 40 million tonnes per year. Inland capture fisheries are expected to increase production only slightly, held back by political and administrative difficulties in parts of the developing world, and competition from sport fishing in the industrialized countries. Thus, under an optimistic scenario of prudent marine management and successful aquaculture, global fish supplies in 2010 could total about 140-145 million tonnes.

Due to the slowdown in global population growth, falling disposable income in the Asian countries affected by the financial crisis of 1997, and anticipated trends in demand among industrialized country consumers, the FAO has revised downward its estimates of future demand for food and non-food fish. Demand in 2010 is now estimated at between 105 and 110 million tonnes for food fish, plus about 30 million tonnes to make fish meal and fish oil, or 135-140 million tonnes in all.

Clearly, this scenario leaves little room for manoeuvre. A financial upturn, an acceleration in population growth, or changing consumer taste could push up demand. More likely, "prudent" marine fisheries management will not suddenly materialize over the next decade. Marine captures for 1997 are believed to have fallen slightly from the level achieved the previous year, the third such decline in a decade. Future gains from aquaculture are also subject to constraints. Many fish farms in developing countries have been improperly managed, leading to self-pollution from nutrients and waste products. A number of Asian countries, including Taiwan, Thailand and Vietnam, have suffered from sudden shellfish production crashes due to viral infections and inadequate health management, and disease is now considered the most limiting factor in shrimp cultivation. These problems are certainly surmountable, but aquaculture also faces competition for the resources of land and freshwater. Inland ponds compete with cropland; coastal ponds compete with a host of other potential uses of valuable coastal zones: urban development, tourism, even golf courses. Most of these sources of competition will make themselves felt most strongly in developing countries.

Policy efforts

Fisheries management is immensely complex, involving disputed allocation rights over a global resource, issues of national sovereignty, private and public sector interests, economic development, employment, and basic food security. Despite the difficulties, the past few years have seen a flurry of activity, at international and national level, aimed at shifting fisheries management onto a less self-destructive course. The 1995 Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks advocates use of the precautionary principle to protect fish which move between EEZs and the High Seas and are therefore vulnerable to being fished twice over. A further important achievement is the FAO's Code of Conduct on Responsible Fisheries (1995) which sets out principles and policies for more sustainable management of the world's marine resources. UNCLOS III (the latest United Nations Convention on Fishing and Conservation of the Living Resources of the High Seas) also contains provisions for more responsible fisheries management, such as requirements for environmental impact assessments and monitoring, pollution controls, and conservation of threatened ecosystems or species.

A major weakness in all such international agreements to date has been unwillingness on the part of important fishing nations to commit themselves. Scientific uncertainty regarding the size of fish stocks and sustainable maximum yields has often been exploited by powerful fishing industry lobbies, and made the pretext for delaying or ignoring implementation requirements. UNCLOS III waited 12 years to come into force and, as of August 1999, only four of the top ten fishing countries have signed and ratified the Straddling Fish Stocks Agreement. Even when in force, monitoring and enforcement of agreements remains an immense challenge, especially for developing countries lacking the financial and sophisticated technological resources required. At national level, a number of countries have implemented measures to restrict entry into their fishing fleets, to encourage exit, or to limit or ban fishing in designated areas. So far, these measures have met with modest success, and have not impinged on the global situation. A clear priority for future international negotiations should be more explicit allocation of resource rights to individual users, and the development of concrete mechanisms, including transnational agreements, to compensate countries and individual fishers who will inevitably lose out as fishing effort is reduced.

Conclusions

Production growth from the largest source of fish supply – the oceans – has slowed markedly and harvests are not expected to rise much further without urgent conservation measures for depleted stocks and more selective exploitation of still abundant stocks. If new management practices are not adopted immediately, marine captures are expected to decline in absolute terms over the next decade. Any shortfall in supply is likely to affect developing countries more than developed ones. As demand and fish prices rise, exports of fish from developing to developed countries will tend to rise as well, leaving fewer fish for local consumption, and putting fish protein increasingly beyond the reach of low-income households.

Aquaculture may prove able to bridge the gap between demand and supply at the global scale. But production from aquaculture in developing countries (which account for over 75% of total production), with the notable exception of China, is mostly for export and will not therefore alleviate domestic scarcity as marine captures peak or decline.

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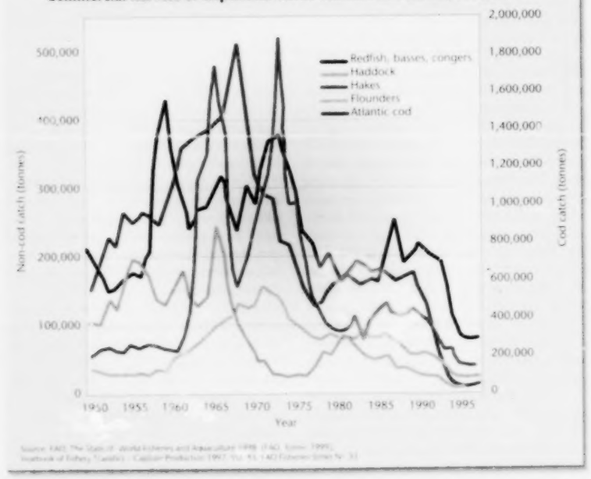
6. A more recent Technical Consultation by the FAO concluded that bycatch rates may have been overestimated, and that the mean discard rate might be closer to 20 million tonnes annually. ◆

Figure 3
Commercial harvest of important North Atlantic fish stocks, 1950-96



The impact of environmental measures on coffee production costs in Latin America

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Abstract
Coffee growing, processing and distribution have both positive and negative environmental impacts. Life-cycle analysis is one of the instruments that can be used to find ways to mitigate the negative impacts. The systématization of a simple model should be complemented by additional analyses of a socio-economic nature. In calling attention to problems associated with the coffee production chain, even with the aim of finding and proposing alternatives adapted to local needs, it should not be forgotten that the coffee industry brings many benefits to coffee-growing areas as well as areas where processing (washing, selection, roasting, grinding and blending) takes place.

Résumé
La culture du café, sa transformation et sa distribution ont des impacts à la fois positifs et négatifs sur l'environnement. L'analyse du cycle de vie est l'un des instruments qui permettent de trouver les moyens de réduire les impacts négatifs. La systématisation d'un modèle simple doit être complétée par des analyses socio-économiques. Attirer l'attention sur les problèmes associés à la filière de production du café, même dans le but de trouver et de proposer des solutions de rechange adaptées aux besoins locaux, ne doit pas faire oublier que l'industrie du café a de nombreuses retombées positives pour les régions productrices, ainsi que pour les régions où est traité le café (lavage, sélection, torréfaction, mouture et mélange).

Resumen
El cultivo, el procesamiento y la distribución del café tienen efectos tanto positivos como negativos para el entorno. Para discernir las vías que permiten mitigar las repercusiones negativas, uno de los instrumentos que deben emplearse es el análisis de los ciclos vitales. La sistematización de un modelo sencillo debería complementarse con análisis de índole socioeconómica. Cuando se centre la atención en los problemas relacionados con la cadena de producción del café, aunque el objetivo sea encontrar y proponer alternativas adaptadas a las necesidades locales, no debe olvidarse que la industria cafetera aporta grandes beneficios a las regiones de cultivo y a los sectores que se ocupan de su procesamiento (lavado, selección, tueste, molido y mezclado).

The coffee plant, an evergreen shrub, is a crop about which there is much to be said with regard to its effects on the environment. In Ethiopia, where *Coffea arabica* originated, it grows in the shade of other trees in upland tropical forests. It has been pointed out that in traditional shade cultivation this plant's ecological profile is very similar to that of the original forest in terms of the biodiversity that can be supported. Traditional growing also produces more organic matter and reduces the need for chemical fertilizers.[2,3] However, even when grown out of the shade, coffee (being an evergreen forest plant) makes a positive contribution to the environment compared to some annual crops or the breeding of livestock.

In fact, the growing, processing and distribution of coffee have a number of separate impacts, both positive and negative, on the environment. The potentially negative impacts, which may need to be halted by corrective action, are generally the use of chemical pesticides and fertilizers, reduction of biodiversity through increasingly technology-based farming, destruction of natural forests through the creation of new plantations, and water contamination caused by concentrations of wet processing plants. Even when calling attention to the problems associated with the coffee production chain, albeit with the aim of finding and proposing alternatives adapted to local needs, it should not be forgotten that the coffee industry brings many benefits, both to rural areas where coffee is grown and to the economy of the areas where processing (washing, selection, roasting, grinding and blending) takes place, not to mention its important social and interpersonal role in the consuming countries.

There are various ways of counteracting the adverse environmental effects that the coffee trade can have on the environment. These may spring from private initiatives or be the instruments of government policies and concerns. Five main groups of measures can be distinguished:

- measures directly affecting production techniques;
- measures to improve standards;
- legislative measures;
- economic measures; and
- agricultural policy and other measures.

Measures directly affecting production techniques

Measures used in agricultural production generally can be applied to coffee production. These are designed to help protect soil, water and air quality and the diversity of species. The use of life-cycle analysis as an approach is being investigated and applied by producer countries like Costa Rica, with the support of consuming countries like the Netherlands. The International Coffee Organization is currently in the process of disseminating and encouraging programmes among its member countries to foster environmentally sound coffee production and processing.

Through training and knowledge diffusion, efforts are being made to establish integrated pest control systems to rationalize the use of herbicides and insecticides as far as possible. The greater use of biological control methods is also helping protect soil, water, air and even the health of the workers, distributors and consumers involved in the chain.

Protecting soil quality

Studies on alternating cultivation of other varieties of leguminous plant to encourage nitrogen fixing and soil conservation have already been carried out in Latin America.[4] Better fertilization control, instruction in how to make natural manure for regenerative purposes, and knowledge of biological species which improve soil drainage and oxygenation are part of the basic knowledge farmers need to acquire. Improved performance in this area depends on support being provided on the agronomic front by farmers' associations, government departments, or public sector agencies and educational institutions in each country.

Protecting water quality

According to the region and the eco-climatic conditions, there is a greater or lesser dependence on the elements. Although crop irrigation control has not been consistently used owing to its high cost, the most urgent problem arises from the "wet processing" of coffee. This process, which causes a high level of water pollution during the washing and depulping of the coffee beans, is a matter of great concern in most countries where the arabica variety is grown. A number of studies have been carried out. Fortunately, efforts in some countries, like Colombia and Costa Rica, have been successful in reducing the large amount of water required by the process and have brought benefits both in preventing water contamination and reducing energy use. In Costa Rica, for example, an active three-year campaign to protect sea water was put in hand in 1992.

Crop renewal, erosion and loss of biological diversity

Crop renewal schemes being carried out to counteract pest infestations are having a detrimental effect on the soil (erosion) as a result of the change in the agro-ecological system. In many cases, because of a lack of knowledge and expertise in agronomic management, there has been a transition from an agro-forest system to one which requires a high degree of phytosanitary control, resulting in an excessive use of pesticides toxic to humans. Cases of this type have been recorded in areas of crop renewal in southern Nicaragua (where the problem of coffee leaf rust was acute) in and after 1976. There are no clear solutions in these cases. Improved instruction and dissemination of knowledge can help reduce the adverse effects on the environment.

Use of an approach based on life-cycle analysis

As mentioned above, the use of an approach based on life-cycle analysis is being investigated and applied in producing countries such as Costa Rica, with the support of consuming countries such as the Netherlands. The International Coffee Organization is in the process of publicizing actions using this approach for its Members, in accordance with its policy of encouraging more environmentally responsible production.

Within this framework, life-cycle analysis is only one of the instruments which can be used to investigate solutions to mitigate negative environmental effects. The systematization of a simple model should be complemented by additional analyses of a socio-economic nature. This would facilitate decisions to adopt viable technological solutions, from both a financial and social viewpoint, for agents involved in the production and processing of this beverage.

Life-cycle analysis is supplemented by agricultural criteria for the proper management of inputs and the recycling of by-products (i.e. integrated production or recycling of husks to produce organic fertilizer).

In the case of processing procedures (drying, washing and roasting) it is proposed to use life-cycle analysis to reduce any negative impact on the environment, while at the same time economizing on the use of inputs such as water, energy and packaging materials.

Measures to raise standards

These comprise a whole range of standards and criteria with which substances, products and processes must comply. They may be established by government regulation or determined by market forces.

Regulations governing the maximum amount of a substance that an industry is allowed to emit to prevent air, water or soil pollution may be provided by the Ministry of Health or Department of the Environment (or local equivalent) in the country concerned. Rules laying down the precise composition of a processed food product are another example of government regulation at work.

But quality standards affecting the form, labelling and presentation of coffee and the composition of packing materials are also dictated by the international market. Pressure to comply with other governments' quality standards for hygiene and environmental protection, and the militancy of consumers concerned with the environment, are inducing coffee producers and processors to search for solutions which are both technologically effective and ecologically sustainable.

We shall now outline some of the standards which are most relevant to the production and processing of coffee.

Standards and pesticides

Pesticides are used at two stages: in the production and care of coffee plantations, and in the transport and storage of bags of coffee, where fumigation is required.

It would be possible to discuss theoretically the environmental regulations applicable in each country to substances such as herbicides and insecticides which are toxic to humans. But these measures are far from being consistent and are linked to other factors such as:
a) discoveries related to harmful effects on health, the environment and nutrition;
b) the international markets of large multinationals. For example, a product which is not sold in one country (because the government in that country has very strict environmental regulations) can be sold in another country depending on phytosanitary control requirements; and
c) discoveries of new and more efficient products which protect against a wider variety of pests and are less harmful to humans and the environment (for example, the so-called "fourth generation" insecticides which act on insect ethology or behaviour, such as synthetic pheromones).

Standards and air quality

Regulations are in force, especially in coffee importing countries, to prevent toxic emissions during the roasting process. These may apply particularly in urban areas.

Legislative measures

To enforce standards, governments have the power to pass laws and enter into international agreements. The producer countries all have national resource codes with which coffee growers must comply. This legislation enables action to be taken to protect natural resources and the environment, although it should be noted that the effectiveness of these measures will be greater to the extent that they are accompanied by education and awareness-raising actions and other encouragement to provide more environmentally friendly alternatives.

Legislation in the consumer countries may also be a determining factor in the search for non-environmentally harmful alternatives. Restrictions on the use of aluminium in packing materials in Germany and the State of California are an example.

At the international level, under Article 35 of the International Coffee Agreement 1994, Members shall give due consideration to the sustainable management of coffee resources and processing, bearing in mind the principles and objectives concerning sustainable development agreed at the Eighth Session of the UN Conference on Trade and Development (UNCTD) and the UN Conference on Environment and Development (UNCED).

Economic measures

Among the measures to encourage environmental conservation available to governments are fiscal incentives and measures linked to international trade. This last type of measure includes tariff concessions. In the European Union it has been possible to use tariff concessions as a basis for indicative plans to protect and regenerate fragile areas. This was done in Colombia in 1991: EU tariff concessions were applied in a project administered by the National Federation of Coffee Growers to protect river basins in coffee-growing regions and ensure that water quantity and quality were adequate for both human and agricultural use.

The suggestion has been made, though not yet implemented, that international agreements (in this case the International Coffee Agreement) could provide a framework within which conservation efforts would be reflected in the price of coffee. This would mean financial measures in the form of a tax on exports or a tariff surcharge.[5]

Guaranteed minimum prices for the producer help foster coffee production at the expense of diversification, where this is a viable option. On the other hand, a non-guaranteed price which, together with other factors, means that the producer cannot be sure that the price he receives will cover the cost of harvesting, may lead to a loss of interest in coffee production. Lack of interest in working the land may result in both the impoverishment of farmers through loss of income, and impoverishment of the soil and of the land after it has ceased to be cultivated. This last point requires us to consider the combined effects of policy in the agricultural, economic, commercial and other fields.

Agricultural and other policies

A country's agricultural and other policies to encourage coffee exports, or crop diversification for food security reasons, may act together to affect the degree of concern for protection and restoration of the environment. There is also the medium-term effect of the price of coffee on the commodity market. If the price remains low for a prolonged period, that can be as damaging as a price which is excessively high.

This combination of factors, with priority being given to export promotion to generate revenue for a country, may result in more weight being given to productivity and (if the producer's income allows) to encouraging the use of larger quantities of fertilizer and disease control products. On the other hand, a combination of these factors with very low world prices and expecta-

tions of losses on the part of the producer may cause a fall in the use of these inputs. The extent to which inputs are not used may in turn (allowing for variations depending on the type of soil) have serious implications for natural resource protection, since untertilized soils will tend to become impoverished and the lack of disease and pest control will jeopardize future harvests of coffee, a perennial crop, unless viable alternatives are available. In some African countries, for example, the use of chemical fertilizers is allowing coffee plantations to become stable, thus removing the incentive to make new inroads into primary forest.

Moreover, these measures are not consistently adopted in all countries. Such measures as integrated pest or biological control, the use of fully biodegradable packing materials, the production of certified "organic" coffee, or growing coffee plants in the shade have been put in hand in some countries but not in others. Some private initiatives have been spurred by incentives as part of government measures; others have been taken in response to the potential demand from consumers, with the aim of making production more environmentally friendly.

Greater awareness of, and commitment to, the conservation of natural resources on the part of governments is reflected in the wide variety of programmes that are now being implemented. An example is the *"Fondo ecologico"*, a conservation fund set up in Colombia in 1991 as part of a plan to increase productivity in coffee-growing areas.

The consumer has also played a vital role in forcing coffee processors to show an interest in environmental protection. Some manufacturers and distributors have responded by introducing products in which the consumer pays, through the distributor, a proportion of the price, which is then used to support environment-related projects. An example is the Coocafe company in Costa Rica, which allocates 25 centavos off the price of each packet of coffee to the environment in that country. However, these schemes, although liked by some consumers, are difficult to supervise and rely on the trustworthiness and good faith of distributors in supporting projects which do actually help the environment. Initiatives like these, as a response to a potential demand from consumers for more environmentally friendly production methods, can actually result in an additional cost to the consumer.

To the extent that environmental policies impact on coffee processing costs (where, for example, producers have to accept very strict laws against water and soil contamination or packers have to develop new technologies at a high initial cost), they may, together with other factors, affect the price levels charged to the consumer. In fact, it has been shown that there could be a 20-25% rise in producer costs if action was taken to ensure high-quality organic or natural coffee production. Encouragingly, this means only a 6-9% rise in the price to the consumer, which has been described as acceptable for at least one major consumer market, Germany.

But one could also see an increase or reduction in costs resulting from these measures that did not affect the price paid by the consumer for a cup of coffee. This arises from the fact that the price of coffee depends on a great many factors, and commodity market prices may not directly reflect the producer's additional costs. The solution lies in the way coffee is sold, which should aim to highlight and raise awareness of the importance of pro-environment measures. This, in turn, requires trust in the original producer, which takes time to establish, or a recognized system of certification.

The link between costs to producers, processors and distributors on the one hand, and environmentally friendly measures on the other, is far from being a positive correlation: one can well imagine that in certain cases pro-environment measures could offset any expenditure by yielding benefits in the form of savings in other inputs; in wet processing, for example, savings in water and energy could lead to reduced costs.

A concerted programme of focused promotion, while at the same time maintaining the emphasis on quality, is probably the most effective way of generating the rewards required to bring about a progressive recognition of the need to comply with production and processing regulations, and hence to make an ongoing positive contribution to the environment in Latin America. With programmes such as "gourmet coffee" and "integrated coffee berry borer control", the International Coffee Organization is firmly committed to the twin aims of encouraging conservation and promoting the economic well-being of producers.

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Africa's first socially and organically labelled coffee

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In July of this year Macefcoop, a small farmers' cooperative in Cameroon, succeeded in shipping its first two containers of organic coffee to Europe. This was the first organic coffee from Africa to enter the Fairtrade market.

In Tanzania, farmers of two villages in Kagera District, members of the Kagera Cooperative Union, are finalizing the conversion to certified organic production.

The Kilimanjaro Native Cooperative Union, also in Tanzania, is working on a pilot project to introduce organic coffee-growing on one of their farms in order to demonstrate to farmers what organic is and how organic production can be implemented.

These three cooperatives are all registered partners of the Max Havelaar Foundation.

Max Havelaar and Fairtrade labelling

The Max Havelaar Foundation was created in the Netherlands in 1988 by non-governmental organizations, trade unions, and consumer and church organizations. Its aim was – and remains – to further fairer trading links between disadvantaged producer groups in developing countries who would otherwise be unable to compete on global commodity markets (coffee, cocoa, bananas, etc.) and commercial partners in the industrialized countries.

To ensure that consumers could buy fairly-traded products, and thus increase the sales of Southern producer organizations, it was essential to work with commercial manufacturers and supermarkets who might also benefit from this new consumer market. Commercial manufacturers were authorized to use the Max Havelaar label on their packets if they respected the Fairtrade criteria and accepted an audit by the Max Havelaar Foundation.

There are currently 17 national fair trade labelling initiatives in Europe, North America and Japan which, in 1997, formed Fairtrade Labelling Organizations (FLO) International. It is this structure that coordinates the work of the national initiatives and ensures the audit of all Fairtrade labelled products from the producer to the consumer.

The main FLO criteria are:

1. a minimum price covering necessary production costs and essential needs;
2. a social premium allowing investment in development projects to be decided on by producers;
3. access to pre-financing;
4. direct trade links with fewer intermediaries; and
5. long-term trading relationships.

These criteria are adapted for each different product to reflect the realities of its production. For plantation products such as tea and bananas, there are supplementary environmental criteria designed to minimize the impact of production on workers' health and the environment. These regulate the use of agro-chemicals and the conditions of their application, soil fertility measures, anti-erosion measures, etc.

Participation and sustainable development

Such measures, and FLO criteria in general, are decided upon in discussion with producer representatives. The objective of Fairtrade is to reinforce marginalized producer groups, so that they can take charge of their own development, by giving them the necessary financial means and market access.

The use of the Fairtrade premium is especially important in this context, as its use presents an object of participation and discussion by all the members of a producer organization about their long-term objectives. Development of this reflection and involvement of the whole community in decision-making is, for Max Havelaar, the basis of sustainable development.

As a market-driven system, Fair Trade labelling depends on the circulation of information to both consumers and producers. The former are sensitized to the links between social justice and environmental protection, not least by the fact that decent prices allow producers to offer a quality product while caring for their land and their physical environment. The latter are encouraged by favourable trading conditions and enhanced contact with the market to develop a longer-term vision of production and trade which necessarily involves the conservation of natural resources to ensure future productivity. One producer organization in Costa Rica has, for example, invested the premium from Fairtrade sales of its own coffee brand in a foundation for the protection of the rainforest.

Developing markets for organic produce

In Europe, the developments in Africa mentioned in the introduction are welcome as consumers are beginning to buy more and more certified organic products. Until recently, consumers of organic coffee opted for the more expensive arabica coffees. Consequently the market for organic robusta coffee (largely produced in Africa) was small, but it is developing as consumers gain interest in cheaper coffees containing robusta. This represents a democratization of the Fairtrade and of the organic markets.

Unable to adjust

What does this demand for organic coffee mean for the producers in the South? The conditions for growing environment-friendly coffee in Africa are quite positive, especially in robusta-growing areas. This coffee is often grown naturally, without the use of chemical inputs. In fact, many farmers already consider their coffee to be organic. However, certified organic coffee from Africa is largely unavailable. There is little awareness of what organic production really comprises, and government extension workers have long encouraged fertilizer and pesticide use.

When robusta producers heard about the growing organic market in industrialized countries, they also calculated the high costs involved in relying on certifying agencies in Europe and America with expensive inspection fees. Producers realized the challenges of obtaining certification. They would need not only financial but also administrative support to negotiate the procedures and special requirements established in industrialized countries.

Small farmers are not able to adjust immediately to new demands in the market. A final product is either organic or non-organic; there is no in-between. Most producers, unable to produce certified organic coffee, therefore lost a potential market.

The process approach

Fairtrade's focus on the socio-economic conditions of farmers and workers does not exclude environmental aspects. On the contrary, the objective of Fairtrade is to structurally improve the living conditions of disadvantaged producers in the South. Fairtrade promotes sustainable development in the widest sense, and the environmental dimension of production can therefore not be neglected.

Fairtrade supports the idea of organic production, which is necessary to guarantee long-term sustainable development, and offers a market for producers to valorize their implementation of sustainable production techniques. At the present time, the organic label is the sole market mechanism available to compensate producers for such efforts.

However, farmers cannot convert their production overnight. They need to be accompanied, in a process of gradual change which allows for their increasing environmental awareness, the consequences for their production volumes and incomes, etc. Fairtrade criteria for producer organizations therefore do not impose organic production. To enter the Fairtrade system, they must share the principles behind environmental sustainability and declare that they will work towards these objectives. This process is closely monitored to improve the situation gradually according to market demand, as well as the capacity and awareness of the smallholder members of the cooperative.

Some registered partners of FLO have already completed the process of organic certification. In such cases, the consumer finds both the Fairtrade

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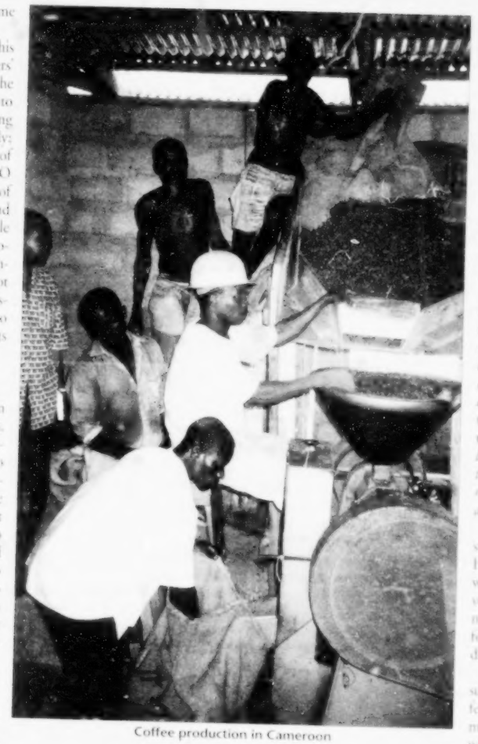
and the organic label on the same retail packaging.

The number having reached this stage is still small. Some farmers' organizations in Mexico, where the idea of Mother Earth is central to the culture, have been producing organic for several years already; others are still at the beginning of the process. However, most FLO partners display a higher degree of environmental awareness and implementation of sustainable techniques than surrounding producers. The development to organic production is often very long, not only due to the difficulty of transforming field practices, but also because of the procedures and costs involved.

Offering a market

Fairtrade plays an important role in this process of organic certification. The Fairtrade premium can facilitate, and is often necessary, to finance conversion towards organic production. Fair trade offers the information link to the market which enables producers to respond to market tendencies and to become certified. Fair trade also offers links with buyers willing to invest (often financially) in order to assure organic coffee deliveries for their clients after certification is completed.

The Fairtrade Labelling Organizations, such as the Dutch Max Havelaar Foundation, have developed criteria which reward organic production with a higher premium from buyers, thus rendering it interesting to producer organizations. The Fairtrade label is gradually coming to stand for a higher standard of environmental friendliness which may one day coincide with the organic label. An example from Africa shows how the process works in practice.



Coffee production in Cameroon

An example from Africa: Macefcoop in Cameroon

As in many other countries, it was difficult for Max Havelaar to establish the direct relationship with farmers in Cameroon which is necessary to enter the Fairtrade system. Until 1992, all exports were regulated by the government. In 1992, the Marketing Board, which held the monopoly of coffee and cocoa marketing, withdrew. Cooperatives and private companies were able to market their own produce.

The new intermediaries did not offer what the farmers expected. *"The traders pay you directly, but they cheat often with weighing scales. They don't show any interest in the problems we are facing,"* says coffee farmer Daniel Bissong from Nchemti, who no longer wishes to work with traders. *"Others first weigh their coffee at reliable addresses in the village before they sell to the traders."* Many farmers began to organize themselves.

One such organization was Macefcoop, at Mamfe near the Nigerian border. The old cooperative, operating both in coffee and cocoa, was completely restructured in 1994. The number of members has increased ever since. Having started with some 30 farmers, it had increased by 1999 to more than 600 members. Daniel Bissong is among its most active members.

Macefcoop's starting situation was far from easy. The new organization lacked the experience and working capital necessary to market large volumes. Macefcoop had neither trucks to collect the coffee beans at the farm gates, nor a factory to process the beans. The cooperative remained largely dependent on the services of traders whose sole aim was to make a profit.

A further problem was the quality of the coffee offered by the farmers. Due to historically low prices, this had suffered tremendously. *"To change that, we had to discuss continuously with the farmers,"* reports Ako Sunny Anselm, the new manager of the cooperative. *"Myself, I have gone from village to village to give explanations to the farmers. I did it on foot as good means of transport were not available and the roads are very bad."*

Macefcoop has much need of support. First contacts with Max Havelaar and Fairtrade importers were established in 1994, but were very laborious due to bad communications. There was little demand for the robusta coffee they produced, and its quality was poor.

However, the farmers wanted to succeed in exporting their own coffee. At first, Fairtrade importers mixed small amounts of the coffee with coffees of other origins. From 1995 onwards, it was introduced into Fairtrade blends. Now the cooperative processes the coffee in its own factory and assures its transport along with cocoa beans to the port of Douala, the point of final sale.

Management and farmers are confident of the success of exporting cocoa and coffee, despite the present small sales. The proposal to produce organic coffee for a developing market was greeted with enthusiasm by the cooperative's members. More than 1000 farmers spontaneously offered to deliver organic beans.

"We never used pesticides and artificial fertilizers," Daniel Bissong explains. *"Only with bother we during the harvesting of the coffee."* An environment-friendly solution was found for the ant infestation, the coffee thus fulfilling organic requirements. However, this did not yet mean that the coffee could become certified. The rules of the European certifying bodies demand exact registration of farmers, creation of a balanced internal controlling system and expensive external inspections, the cost of which easily surpasses US$ 7000.

With support from buyers and a European NGO, as well as the higher price received for their sales by the Fairtrade system, Macefcoop has been able to overcome the obstacles to certification. In June 1999, Macefcoop's coffee was formally recognized as organic. The next month, the first 600 bags of certified organic robusta coffee left the port of Douala – the first socially and organically labelled coffee from Africa.

A review of the contribution of livestock to food security, poverty alleviation and environmental sustainability in Sub-Saharan Africa

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Abstract

Unlike developed countries, where people often eat too many animal products, most of the population of Sub-Saharan Africa eats too little of this type of food for good nutrition. The projected increase in demand for livestock in Sub-Saharan Africa will have an important influence on food security and poverty alleviation. Livestock are vital to meeting agricultural productivity and sustainability objectives. As components of mixed crop-livestock farming systems, they play a critical role in the development of environmentally sound production systems. Where livestock have negative environmental impacts, this may be due to policy distortions and poor regulatory enforcement.

Résumé

Contrairement aux pays développés où l'on consomme souvent trop de produits animaux, la plupart des populations d'Afrique sub-saharienne n'en consomment pas assez et de ce fait ne bénéficient pas d'une alimentation équilibrée. L'augmentation prévisible de la demande en bétail en Afrique sub-saharienne aura une influence majeure sur la sécurité alimentaire et la lutte contre la pauvreté dans cette région. L'élevage est vital pour atteindre les objectifs de productivité et de viabilité de l'agriculture. En tant que composante des systèmes agricoles mixtes (élevage-cultures), il joue un rôle primordial dans la mise en place de systèmes de production respectueux de l'environnement. Les impacts négatifs de l'élevage sur l'environnement sont souvent dus à des distorsions des politiques et à l'inapplication des réglementations.

Resumen

Al contrario de lo que ocurre en los países desarrollados, donde gran parte de la población consume productos animales, la mayoría de los habitantes del África Subsahariana no consume los suficientes para que su nutrición se considere adecuada. La creciente demanda de ganado que se prevé por parte de esta región afectará profundamente a la seguridad alimentaria y los esfuerzos para mitigar la pobreza. El sector ganadero es esencial para alcanzar los objetivos de productividad agrícola y sostenibilidad fijados. En tanto que integrante de los sistemas mixtos agroganaderos, desempeña un papel fundamental en el desarrollo de sistemas de producción positivos para el entorno. Si la actividad ganadera tiene en ciertas regiones efectos medioambientales adversos, se debe a la mala gestión y la laxitud en la puesta en vigor de las normas.

Introduction

Demand for animal products in Sub-Saharan Africa (SSA), and generally in the developing countries, is likely to increase significantly as a result of population growth, urbanization, and rising income compared with relatively low consumption levels at present. This increase has profound implications for food security, poverty alleviation and the environment. Livestock production has often been blamed for harming the environment. Scenes of devastated rangelands in the Sahel are familiar, and the media lay the blame on overgrazing. As an integral part of the farming system, livestock actively contribute to the sustainability of agricultural systems by 1) utilizing crop residues and other feeds which cannot be used by humans and converting them to milk and meat; and 2) providing manure (for soil amendment) and traction (for timely cultivation and intensification) and acting as a reserve to be converted into cash in times of need.

Increased livestock production, in fact, contributes to improving food security and poverty alleviation in the developing world in several ways. Firstly, many poor smallholders have direct access to more food of livestock origin and can earn cash income through sales of livestock and livestock products. Secondly, livestock ownership contributes to greater aggregate cereal supply because of improved farm productivity through traction. Thirdly, increased production keeps livestock product prices down and allows low-income groups access to such food. Producers gain in the face of lower prices because the price and income elasticities of livestock products are higher than those for crops, so that lower prices make possible increased demand, production and farm revenue. Livestock, especially dairy animals, can make unique contributions to the nutrition, and especially the micro-nutrient and health status, of smallholder household members. In contrast to the developed world, where a lot of people eat too many animal products, most people throughout Sub-Saharan Africa eat too little animal products for good nutrition. Under these circumstances, increased milk consumption has a significant positive effect on the nutritional status of household members, especially children.

In this article the empirical evidence concerning the contribution of livestock to food security, poverty alleviation and environmental sustainability is reviewed. The next section is about trends in livestock demand and supply and their projections to 2020. The role of livestock as a source of income, food and nutrient supplies is then presented. The implications for poverty alleviation are derived from this section. Finally, linkages between livestock and the environment are addressed.

Trends in livestock demand and supply in Sub-Saharan Africa

Of all the developing regions, SSA has the lowest per capita meat and milk consumption level. In 1993, SSA inhabitants consumed an average of 9 kg of meat and 23 kg of milk, compared to 21 kg meat and 40 kg milk in the developing world (Table 1). In the early 1980s, per capita consumption of meat and milk stood at 10 kg and 32 kg per person. Between 1990 and 1995, per capita GNP in SSA fell significantly (1.3% per year), explaining the region's decline in per capita consumption of meat and milk during the period (1983-93). However, beginning in the early 1980's, total meat consumption in SSA grew at 2.2% per year thanks to a rapid population and urbanization growth rate. Between 1970 and 1995, population grew at about 3% per year and urban population at 5% per year (the highest in the world). People in SSA get less than a third as many calories and less than half as much protein from animal products as people in the developed world (Delgado et al., 1999). These low consumption levels give an indication of the extent to which animal food product

The agri-food industry

consumption in SSA can grow.

Indeed, the scope for further increases in demand for livestock products as a result of urbanization is still larger in Africa, where the share of population in urban areas is still low and prospects for income growth are high. Projections indicate a 3% per year increase in income in SSA, and for 2025 it is projected that 55% of the population in SSA will live in urban areas (de Haan et al., 1997). Delgado et al. (1999) project that total consumption of meat and milk in SSA will grow at 3.5 and 3.8% per year, respectively, between 1993 and 2020. As a consequence, per capita consumption of meat and milk in 2020 will be 11 kg and 30 kg, respectively (Table 1). Aggregate consumption of meat in SSA will increase from 5 million metric tonnes (mmt) in 1993 to 12 mmt in 2020, an increase of 3.5% per year over the 25-year period. Similarly, it is projected that total milk consumption in SSA will increase from 14 mmt in 1993 to 31 mmt in 2020 (Table 2). Over the same period, developing country aggregate consumption of meat and milk is projected to grow at 2.8 and 3.3% year respectively, compared to 0.6 and 0.2% in the developed world.

Projected production of meat and milk follows the same trends. Delgado et al. (1999) project that meat and milk production will grow at 3.4 and 4.0% annually between 1993 and 2020. It is interesting to note that SSA has the highest growth rates of all countries (Table 3). While total milk demand is likely to be met by domestic production, it appears that SSA will continue to be a net importer of meat.

Livestock as a source of income, food and nutrient supplies

Considerable evidence from field studies of rural households in Africa shows that rural poor farmers and the landless presently receive a higher share of their income from livestock than do better-off rural people (Delgado et al., 1999). Indeed, animal products are a critical source of income for many smallholders in developing countries. Dairy production is the most important income generator in many countries. Where dairy development has been promoted among smallholders, such as in Kenya, it has been shown to increase incomes, consumption and repayment capacity. Sansoucy (1995) also reports that an FAO/UNDP dairy project in Burkina Faso assisted 100 families to increase their monthly income by about US$ 80, which is equivalent to an extra labour unit per family. Furthermore, goat, sheep, poultry and rabbit husbandry, especially in back yard production systems, provides an important source of part-time job opportunities, particularly for landless women and children. At farm level, cash is generated regularly from direct sales of livestock products such as milk, eggs and manure, and occasionally from the sale of live animals, wool, meat and hides and from fees for draught power or transport services.

In semi-arid Mali, livestock was reported to contribute 78% of cash income from crops and livestock in smallholder mixed farming (Debrah and Sissoko, 1990, cited in Ehui et al., 1998). In the Ethiopian central highlands, Gryseels (1988, cited in Ehui et al., 1998) showed that the sale of livestock and livestock products contributed 8.5% to cash income per year. About 52% of cash income was from the trade of animals and 31% from the sale of livestock products. Manure alone accounted for 25% of the sale of livestock products, and dairy products just over 50%. In Senegal in the early 1990s, Kelly et al. (1993, cited in Delgado et al., 1999) found that an average of 24% of the income of the lowest one-third in the income stratum come from livestock, while only 14% came from livestock for the highest one-third of the household income stratum.

Livestock ownership has a significant impact on overall farm productivity, and hence food production. Savadogo et al. (1994, cited in Ehui et al., 1998) showed that in the case of Burkina Faso, average productivities of land are higher among households which use animal traction than those which cultivate manually. In another study, Savadogo et al. (1996, cited in Ehui et al., 1998) showed that aggregate food supply responses to increases in the prices of maize and cotton (cash crops) are higher in animal traction than in manual cultivation households. Their results demonstrate that households which invested in farm capital such as animal traction could respond more positively to export cash crop (maize and cotton) incentives than could manual households. In addition, non-price factors such as land, fertilizers and manure had a larger impact on aggregate food supply among traction households than among manual households. They concluded that donors and government programmes which promote adoption of animal traction could reduce structural constraints that impede farmers' ability to respond to policy changes. Thus, policy should reinforce programmes such as animal traction.

Besides containing important nutrients, especially carbohydrates, protein and calcium, meat and dairy products contain essential micronutrients in bioavailable form such as vitamin A (retinol), the B-complexes and zinc, all essential for growth and proper physical and mental development. Evidence is mounting that the bioavailability of vitamin A in carotene-rich leafy green vegetables is much lower than previously believed (Gillespie and Mason, 1994, cited in Ehui et al., 1998). Studies by the Human Nutrition Collaborative Research Program (CRSP) in Kenya have shown that children deprived of Vitamin B_{12} – which comes only from animal products – suffer impaired learning abilities and do not develop their full human potential. Realization of the importance of livestock products in diets needs to be translated into support for livestock development among the rural poor in developing countries. In Sub-Saharan Africa, animal products contribute about 7% of all calories and 20% of all proteins in the diet, whereas in developed countries animal products provide about 27% of all calories and about 50% of all proteins in the diet. In the developing countries, where diets are composed of only a small number of staple foods, animal products are therefore of great importance in preventing malnutrition. They are concentrated sources of essential amino acids, available in only limited quantities in the protein of staple vegetable foods.

Figure 1
Effects of applying manure and artificial fertilizers on sorghum crops in Burkina Faso over 30 years

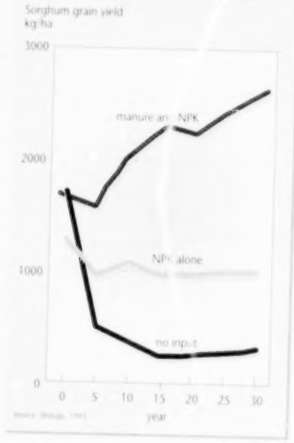

Table 1
Per capita consumption of meat and milk by region in 1983, 1993 and 2020 (kg)

Region	Meat			Milk		
	1983	1993	2020	1983	1993	2020
China	16	33	60	3	7	12
India	4	4	6	46	58	125
Latin America	47	46	59	93	100	117
Sub-Saharan Africa	10	9	11	32	23	30
Developing world	14	21	30	35	40	62
Developed world	74	76	83	195	192	183
World	30	34	39	76	75	85

Source: Delgado et al., 1999

Livestock and environmental sustainability

Rapidly increasing livestock production can cause serious damage to the environment, but livestock can also have beneficial environmental impacts. Animals will likely be produced intensively in areas where financial capital is cheap relative to the price of land, for example where there is the likelihood that credit subsidies targeted to large enterprises or prohibitive loans to smallholders will artificially promote industrial systems at the expense of the small producers. Degradation of the environment is likely to occur in places where land is "free" and government policies constrain the mobility of animals, settle pastoral people, enhance food self-sufficiency, and increase commercial off-take of livestock from the rangelands with little or no regard for the temporal and spatial variability of rangeland production.

The rapid expansion of livestock production in SSA causes animals and people to be concentrated around major cities in the periurban areas (e.g. Addis Ababa, Dar-es-Salaam). These concentrations of people and animals generate public health concerns due to the increased risk of the incidence of zoonotic diseases such as infections from salmonella, *E. coli* and avian flu. Furthermore, with the increased consumption of livestock products in SSA, there are food safety risks associated with microbial contamination. Major factors contributing to public health concerns include, among other things, poor public infrastructure, high transport costs, and lack of appropriate technologies and regulatory frameworks. Thus, policies that remove distortions that promote artificial economies of scale, improve the regulatory environment, and improve property rights institutions will permit livestock production to contribute to the environment in a sustainable manner.

These policies will not work unless regulatory enforcement backs them up. Global concerns about the generation of greenhouse gases, biodiversity loss, overgrazing and desertification of dry lands, and the maintenance of soil and water quality are increasing as human populations grow. Livestock undoubtedly contribute to these problems, but the allegations against them are often exaggerated or unfounded. Livestock production contributed only about 1% of carbon dioxide emissions in Africa in 1993. Livestock and manure management contributes about 16% of the total annual production of methane worldwide. Emissions are highest where both animal productivity and feed quality are low, indicating that increasing productivity through the use of improved feeding strategies would reduce methane emissions from ruminants. The misconception that desertification and land degradation in semi-arid and arid rangelands are caused by livestock is still debated, although the positive contribution of livestock has also been recognized.

Environmental concerns are real, but the needs of poor rural people must also be taken into consideration. Improved agricultural systems must meet the desires of people, or they are doomed to fail. They must also be flexible enough to evolve and develop if they are to continue to meet the changing needs and desires of society. To a large extent, this means increasing output through productivity increases. Increasing output and preserving or improving the environment may seem mutually exclusive goals, but both can be achieved through judicious marshalling of resources.

Research at the International Livestock Research Institute (ILRI) shows that livestock can play a vital role in meeting both productivity and sustainability objectives. They are central to nutrient cycling. Interactions between crops and livestock are important to the efficiency, stability and sustainability of farming systems in the developing world. Any alteration in resource flows can lead to changes in the performance of either the crop or livestock sector. As components of mixed crop-livestock farming systems, livestock play a critical role in the development of sustainable and environmentally sound agricultural production systems. The use of livestock fosters intensification, an alternative to expanded cultivation of marginally productive lands that may be vulnerable to degradation.

Manure is among the most important contributions that livestock make to intensification and sustainability. Although it cannot replace all of the soil minerals removed by the harvested crops, it recycles a significant proportion and adds organic matter that contributes to the tilth and water-holding capacity of soils. Manure is often the only fertilizer available to farmers in the developing world and contributes as much 35% of soil organic matter in some areas. Figure 1 reports the results of a long-term experiment in Cote d'Ivoire. Continuous application of a 3:1:1 ratio of NPK (nitrogen, phosphorus, potassium) shows that initial yields were apparently affected by previous cropping history. The application of a combination of manure and NPK raised yields of sorghum over time (Sedogo, 1993).

Significantly, livestock provide an entry point for practices that help promote sustainable use of land resources, such as introducing forage legumes in the cropping systems. As agriculture becomes more intensified, legumes grown to feed livestock can also provide nitrogen for crop production. At forest margins in the humid tropics of Sub-Saharan Africa, planting of legume-based pastures and leguminous trees as forage for ruminants could provide economic alternatives to slash and burn cultivation and ease pressure to move into the forest. An indication of the potential which comes from ILRI's work lies in fodder banks – small, intensively managed pastures of forage legumes intended initially to provide high-quality dry season feed for cattle in sub-humid West

Table 2
Total meat and milk consumption (1993 and 2020) and projected trends (1993-2020), by region

Region	Meat (mmt)		Milk (mmt)		Annual growth rate of consumption 1993-2020 (% per year)	
	1993	2020	1993	2020	Meat	Milk
China	38	85	7	17	3.0	2.8
India	4	8	52	160	2.9	4.3
Latin America	21	39	46	77	2.3	1.9
Sub-Saharan Africa	5	12	14	31	3.5	3.8
Developing world	88	188	168	391	2.8	3.3
Developed world	97	115	245	263	0.6	0.2
World	184	303	412	654	1.8	1.7

Source: Delgado et al., 1999

Night tethering of small stock in Niger. Through strategic use of night tethering, Sahelian farmers apply manure on the "bad spots" and "tired soils" of their cropping fields that are most in need of nutrients and organic matter.

Table 3
Projected trends in meat and milk production, 1993-2020

Region	Projected annual growth of total production 1993-2020 (% per year)		Total production in 2020		Per capita production in 2020 (kg)	
	Meat	Milk	Meat	Milk	Meat	Milk
China	2.9	3.2	86	19	60	13
India	2.8	1.6	8	172	6	135
Latin America	2.2	2.0	39	80	59	123
Sub-Saharan Africa	3.4	4.0	11	31	10	30
Developing world	2.7	3.2	193	401	29	61
Developed world	0.7	0.4	121	371	87	267
World	1.8	1.6	303	772	39	100

Source: Compiled from Delgado et al., 1999.

Africa. While fodder banks were originally targeted at livestock owners, they can have dramatic benefits for food crop production. These benefits are vitally important, since most land is in the hands of crop farmers who keep no livestock. ILRI research has shown that maize produces up to 2.5 tonnes more grains per hectare on land that has been under a fodder bank for two or three years than on land that has been left fallow for six years. Added to that, the soil is easier to till following the legumes, making life easier for the farmer. The soil is under plant cover for most of the year, protecting it from wind and rain erosion, and livestock productivity is increased. All round, farmers, livestock owners and the environment benefit. But without cash-generating livestock, there would be less incentive for crop farmers to plant legumes.

Another aspect of livestock production that offers prospects of boosting the sustainability of many of the developing world's farming systems is animal traction. By mechanizing field operations, particularly cultivation and weeding, animal traction opens up a range of options for farmers. For example, in the East African Highlands ILRI has demonstrated that improved soil management using animal-drawn implements offers the possibilities of early planting of long duration from, for example, improved bread wheat or double-cropping of a forage crop and a traditional short-season crop.

Without animals, which continue to produce milk and meat during all but the severest and longest droughts, human life and livelihood in the Sahel would be impossible.

Research in ruminant genetics and health can contribute to protecting the environment by identifying and promoting the use of disease-resistant livestock. Keeping such animals reduces the use of chemical control measures and hence the amount of chemicals entering the environment and the food chain. Better-adapted and more productive livestock can be used for traction, reducing the use of fossil fuels and soil compaction from mechanized ploughing.

Policy is another important factor determining the impact of livestock on the environment, especially in fragile environments under collective management. In collaboration with the International Food Policy Research Institute (IFPRI), ILRI's research on policy options for sustainable land management is providing an understanding of the conditions under which livestock farmers degrade or improve their land to inform policy makers on the impacts of livestock under different policy options. Research on property rights, risks, and policies for managing grazing and feed resources will help identify policy options that can be used to reduce environmental degradation.

There are opportunities through livestock production to break the desperate cycle of increased cropping, land degradation and poverty. Livestock production needs to be seen not as an end in itself, but as central to the development of sustainable, farming systems for developing countries. Increasing livestock production, in all its forms, can contribute to improving human nutrition and increasing farm income, which in turn are likely to lead to increased investment in crop production – better seeds and fertilizer. As standards of living rise, so do investments leading to better human health and protection of the environment.

Note

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Environmental practices in meat processing plants: experience in New Zealand

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Abstract
The evolution of the meat processing industry in New Zealand is reviewed, particularly with regard to environmental impacts. Despite great progress in waste reduction and by-product recovery and processing, meat processing continues to produce large amounts of waste. Considerable waste reduction opportunities therefore exist. Environment-related procedures and standards are influenced by the need for cost-effectiveness in an international context; the need to comply with national regulations as well as those of importing countries; and a variety of commercial quality requirements. Under new legislation, New Zealand meat processors are required to prepare and implement risk management programmes.

Resumé
L'article fait le point sur l'evolution de l'industrie de la transformation de la viande en Nouvelle-Zélande, notamment du point de vue de ses impacts sur l'environnement. Malgré d'énormes progrès en termes de réduction des déchets et de récupération et traitement des sous-produits, cette activité continue à produire d'importantes quantités de déchets. Il reste donc beaucoup à faire dans ce domaine. Les procédures et normes relatives à l'environnement sont soumises à des impératifs de rentabilité liés au contexte international, à la nécessité de respecter les réglementations nationales et celles des pays importateurs, et enfin à diverses exigences commerciales de qualité. La nouvelle législation néo-zélandaise exige de l'industrie de transformation de la viande qu'elle élabore et mette en œuvre des programmes de gestion des risques.

Resumen
La evolución de la industria de procesamiento de carne en Nueva Zelanda se está poniendo en tela de juicio, sobre todo en la concerniente a las repercusiones medioambientales. A pesar de los grandes progresos obtenidos en la reducción de desechos y la recuperación y procesamiento de productos derivados, esta actividad continúa generando cantidades considerables de residuos. Sin embargo, existen muchas vías para reducirlos. Los procedimientos y estándares que protegen el entorno están influidos en el ámbito internacional por la rentabilidad, por la necesidad de respetar la normativa nacional y la de los países importadores, y por una serie de requisitos comerciales relativos a la calidad. De acuerdo con la nueva legislación, las plantas neozelandesas procesadoras de cárnicos deben elaborar y poner en vigor programas de gestión de riesgos.

Introduction

The processing and export of red meat products (beef and sheepmeat) is New Zealand's oldest export industry. The growth of the industry from its early rural beginnings played a major role in transforming the country's largely unmodified and unpeopled landscape into a productive agricultural economy.

The first shipment of frozen carcasses took place in 1882. By 1900, the volume exported had reached 93,000 tonnes. Through the present decade the annual volume of export meat product has averaged one million tonnes. Until the mid-1980s, the industry was New Zealand's biggest earner of overseas revenue. In 80 processing plants employing one of the largest workforces in the country. The industry is energy intensive, and a major user of utilities such as electricity and water.

The New Zealand meat industry has undergone substantial rationalization in the past decade and a half, as stock numbers have fallen 40% from a peak of 75 million sheep to 45 million today. Many long-standing plants have closed, while others have been upgraded to meet competitive pressures and new hygienic regulations, and to maximize the use of improved technology. During this period of rationalization there has been a withdrawal of livestock farming from marginal land, and a corresponding shift to alternative forms of land use such as increased dairy farming and forestry.

Legislative backing for environmental protection in New Zealand lies in the Resource Management Act 1991, which has as its overarching purpose the sustainable management of natural and physical resources. The Act is not a prescriptive set of standards and criteria to be applied across the country. Rather, it is an enabling framework that provides for integrated management of the environment at three levels of government – national, regional, and city or district. Provision is made for National Environmental Policy Statements and National Environmental Standards, but in the Act's first eight years of life only one such national statement has been made: the National Coastal Policy Statement. In contrast, every region in New Zealand has prepared regional policy statements and, in many cases, resource management plans that deal with issues specific to the area such as solid waste management, air and water quality, coastal protection, land use and subdivision.

Within the plans, provision is made for existing or intended activities in a hierarchy depending on the activity's potential impact on the environment. Specific environmental impacts can be controlled by rules which have the force of regulation in law. Although many common activities are regarded as permitted activities, many activities related to meat processing in particular require to be authorized by site-specific resource consents. In the absence of prescriptive national environmental standards, most consent authorities adopt existing international standards or emerging New Zealand guidelines in order to define quantified numerical standards for such resource consents.

Environmental impacts related to meat processing

The environmental practices pursued in New Zealand meat processing plants are not discrete activities, but essential links in the value chain that has its origin in the contribution of the producer who provides the livestock for processing. What occurs in the plant has a seamless relationship with aspects of the quality assurance systems that companies require of their suppliers at farm level. The "life cycle" in the figure illustrates the range and diversity of the environmental inputs – the "impacts" – that meat producers, processors and marketers have to address along the value chain. Also shown – a selection of the outputs – the "responses" – being made to meet and manage the challenge.

The focus on the farm as the first step in the supply chain has led to the development of Land-care Groups dedicated to sustainable farm practices and good environmental management. These programmes often combine food safety objectives with environmental management, in order to safeguard the productive base of the agricultural economy.

To maintain a reputation in the marketplace as a source of premium food items, the meat exporter must be able to give confidence that its products are safe and disease free, and that they are sourced from animals reared under favourable welfare conditions and in a farm management setting that puts a priority on sustainability and biodiversity.

protection. To that end, the preferred on-farm procedures carefully monitor live animal management practices, pre-slaughter treatment and presentation of livestock, and the incidence of any disease or other hazard that might threaten the safety of the ultimate food product.

A national database of farm location and management has multiple uses; for example, monitoring pest and disease control, measuring livestock density, measuring livestock emissions, and raising understanding of the relationships between land use and environmental quality indicators.

A feature of much of the New Zealand meat industry is the degree of integration of its processing operations. It is common for slaughter and fabrication to occur on the one site. Likewise, all parts of the animals are usually dealt with on-site. The edible parts may be processed and packaged to retail-ready form for sale on the world market chilled or frozen. Inedible parts including blood, bones, off-cuts and wool, skins and hides are often processed fully on the same premises. This combination of operations results in unique environmental challenges, as large quantities of water and energy are required. However, the same integration of activities provides the opportunity to minimize waste generation at source, and to allow a degree of water reuse as product progresses through the production chain.

Changes in environmental practices

As noted above, the quest for operational efficiencies and considerations of food safety shape environmental practices. In addition, those practices have progressively been modified as the industry has evolved. The volume and management of resource input that was adequate when the end result was predominantly in frozen carcass form is not appropriate for plants that now release up to 90% of their product in finished cuts and turn out more chilled items than frozen.

Energy

For example, energy typically accounts for about 5% of plant running costs. The trend in recent years has been to fuel-efficient plants, to 6- to 8-s processing, and greater automation. This has seen a notable switch from coal and oil to electricity and gas. On the other hand, increased processing requires higher mechanization, more air conditioning, and a clean and well-lit workplace; those increase environmental measures.

Notwithstanding the market driven pressures towards products that require greater energy commitment, the meat processing industry is a willing party to a voluntary agreement with the New Zealand Government under which the target is to reduce CO_2 emissions per tonne of meat processed by 20% between 1990 and 2000. Major improvements in energy efficiency are being made through low-temperature rendering, heat recovery and cogeneration, pinch technology, water recycling, thermal insulation, mince condensate recovery, and better on-site refrigeration technology. Improved target setting and benchmark reporting also have a significant role. Many plants have developed effective waste minimization programmes to avoid creating environmental problems at source.

Energy intensity is also being lowered by greater use of electricity at the expense of coal and oil, as well as increased use of natural gas to heat water close to its point of use, thereby saving steam transmission losses. Using gas in drying operations also reduces steam transmission losses and boiler efficiency losses.

Wastewater

Along with energy sources, meat plants also consume huge volumes of water. To one day the typical plant would use an amount of water equivalent to a city with a population of 60,000. Accordingly, wastewater treatment and discharge is a major concern. In the industry's early years, untreated water was often discharged directly to the sea.

Today all plants have primary treatment utilising such equipment as millscreens, settling and flotation units, solid thickeners and centrifuges. This equipment removes oils, grease and solids from the waste streams. Unless feeding into a municipal waste system, plants normally have secondary treatment, usually anaerobic and aerobic ponds which need to be substantial because of the volume of trade waste involved. Many processing plants have developed access to water stocks that are independent of the community supply sources.

The first abatement systems relied on irrigation onto pasture. Where local circumstances are suitable, such as area and subsoil conditions, this remains one of the preferred methods of wastewater disposal and is widely used. Nowadays it is accompanied by careful control of loadings and extensive monitoring to ensure that there are no adverse effects on ground waters. As with all such systems, there is a periodic need to extract deposited sediment and accumulated biomass. Such solid wastes may be ploughed into pasture land as a raw but effective fertilizer. In some instances, however, all solids, including those from ponds, wetlands and stockyards, are composted to create soil conditioning material, thereby following the trend of making value added products out of what was previously waste.

The pristine nature of many New Zealand streams and rivers, renowned for their trout and salmon fishery, places a high premium on preserving water quality. In order to maintain this, use is being made of some instances of *artificial wetlands* prior to discharge to natural waters.

The concept of artificial wetlands is not new. The application to meat industry wastes, with their high volumes, suspended solids, biological oxygen demand (BOD) and nitrogen loadings, has been a challenge. Several different systems have been tested. These have included both surface and sub-surface flow systems, with various plant species and different effluent types. In general terms these achieve results which are better than the more traditional treatments, particularly with regard to BOD and suspended solids. Nitrogen removal is also effective, although this appears to be influenced by temperature, being greater in summer than winter. It is also influenced by the age of the wetland, as the increased carbon mass of the more established wetlands aids the denitrification process.

Odour

Most meat processing plants in New Zealand have an associated rendering plant. The control of odour from these is a significant and continuing challenge to the industry. One approach adopted in New Zealand is the use of biofilters; these work by directing odorous gases through a biological medium where the odorous compounds are removed by physical, chemical and biological processes. They have proved an effective method of controlling odour, but they require careful design and maintenance. Short circuiting and high aeration back pressures must be avoided, and a good control kept of moisture. The method's success is demonstrated by the fact that about half of all rendering plants in New Zealand make use of biofilters.

Stickwater

Another waste stream from the low temperature rendering processes used in New Zealand is "stickwater". This is the aqueous phase by-product of a separation step in which tallow is removed from a mixture of tallow, protein and water. While low in volume, stickwater has a very high chemical oxygen demand (COD) and so can have a high impact on plant effluent loadings. Some plants use a system of evaporation to prepare this stickwater for drying. Ultrafiltration has also been explored as an alternative, and investigations continue into improved ways of handling this by-product.

Waste reduction and recovery

Much of the credit for developing effective environmental response practices in New Zealand meat plants goes to the Meat Industry Research Institute of New Zealand (MIRINZ). This institute has an international reputation, for example with regard to its pioneering work on controlled atmosphere packaging. Another excellent example of MIRINZ' innovative research is the work of Albert van Oostrum in the field of waste minimization (see *Waste Minimization in Meat Processing* and ROAMST, 1997).

With increasingly strict standards and restrictions being imposed on how wastes can be disposed of, most meat processing companies are facing the challenge of improving their waste management practices while keeping costs to a minimum. Mr van Oostrum has specialized in the study of methods to reduce the environmental impact of wastewater, which is the largest waste stream from meat processing. The following section draws upon his work.

At animal slaughter and processing plants, various amounts of blood, fat, gut contents, faeces and other organic materials are washed into the effluent stream. The resulting effluent typically contains high concentrations of BOD, nitrogen, phosphorus and faecal microorganisms, all of which are pollutants of concern in the treatment of the wastewater and its discharge to the surrounding environment.

Once organic materials enter the effluent stream, they add to its treatment and/or disposal costs. Some of the effluent particulate solids can be removed by primary treatment systems such as screens, sedimentation tanks and dissolved air flotation (DAF) systems. However, only a small proportion of the wastewater pollutant load can be removed by these simple physical means. Most of the wastewater load is in a soluble or colloidal form, and can be removed only by using more complex secondary treatment techniques such as ultrafiltration, chemical treatment, biological treatment or land application. The cost of such treatment is high, and is directly related to the volume of the wastewater, the concentration of pollutants it contains, and the degree of pollutant removal required.

As the required standards, and therefore costs, of waste treatment and disposal increase, there is an increasing economic incentive for processors to reduce waste production at source. Source reduction, as applied to minimizing the contamination of a process water stream, can be achieved by either changing the process to avoid the use of water, or reducing the amounts of material that enter the process water. In meat processing, the latter approach often involves dry cleaning techniques (i.e. cleaning that does not use water, such as sweeping), and then either disposing of the recovered material or processing it into products with a commercial value. Thus, an added incentive for source reduction is that it can increase revenue.

While reduction of wastewater loadings is rarely a viable, the next best option is to reduce wastewater loadings in order to recover waste from the effluent stream by physical and/or physico-chemical treatment. In meat processing, this is often accomplished by segregating appropriate waste streams and recovering the materials from these waste streams as close to the waste sources as possible, in order to maximize the quantity and potential value of the materials recovered.

When assessing opportunities for reducing and recovering wastes in meat processing, it is useful to distinguish between potentially useful wastes derived from animal tissues (e.g. blood, fat, meat and bone) and low- or no-value wastes consisting of the animal gut contents, faeces and urine. Any animal tissue waste material stood from entering the wastewater stream or recovered from the wastewater can be processed and saleable by-products such as tallow, meat and bone meal or dried blood, as appropriate. Thus, these materials contribute to "waste," only if they are washed down the drain.

Waste minimization applied to gut contents and faecal material is more complex. As with waste animal tissues, collecting the gut contents and faeces in a "dry" form (e.g. dry dumping paunch contents and dry collection of farmgate wastes) can considerably reduce the effluent pollutant loading and treatment/disposal costs. However, the "dry" collection of these solids can be difficult, and the collected solids themselves are a significant disposal problem for many meat processing plants.

Faecal matter and gut content enter the meat plant effluent stream from various sources:

- stock truck washing,
- washing of yards used for pre-slaughter holding of stock (lairage),
- paunch opening and trips recovery,
- casings washing of viscera for the production of natural casings for sausages.

The usual practice for managing the faeces and gut content is to wash them, using large amounts of water, into the wastewater stream. For meat plants that do not carry out on-site rendering or other means for product processing, operations

of effluent streams containing the two categories of waste (animal coats vs. low-value or no-value wastes). Often, millscreens and/or screw-presses are used to recover and de-water the faecal and gut content solids.

As with other meat plant solid wastes, dry collection of faeces and gut content gives much better recovery of the organic matter and nutrients in the solids than any practicable form of wet recovery. An added benefit of dry recovery is that water is conserved.

Mr van Oostrom's valuable studies highlight that the meat processing industry, despite having made major advancements in waste reduction and by-product recovery and processing, remains a large producer of waste. Opportunities remain for reducing the amount of animal tissues and faecal/gut content material that enters the processing wastewater. These opportunities include techniques that recover wastes in a dry form before they are washed into the wastewater.

Where such wastewater loading reduction at source is not viable, the pollutant loading on costly secondary wastewater treatment systems can be reduced by appropriately segregating waste streams and recovering the waste solids and potentially valuable materials from these waste streams as close to the source as possible. As the costs of wastewater treatment and disposal increase, the economic incentives to improve waste reduction also increase. Both good management and an understanding of "downstream" consequences of processing practices and technologies are essential to achieving success in waste minimization.

Conclusion

The New Zealand meat industry's constant goal is to reduce the impact of its activities on the environment by identifying and meeting international standards of best practice. Three sets of demands influence what precise environmental procedures and standards are applied in New Zealand meat plants. First, in a global industry renowned for robust competition, New Zealand meat exporters must strive to be internationally cost-competitive. This means extracting efficiencies and cost savings from their plant operations wherever possible, investing heavily in new technology, and taking advantage of New Zealand's flexible labour market policies.

Secondly, as a substantial processor and exporter of perishable food items intended for human consumption, the industry must comply with stringent sanitary and pH (unsanitary specifications laid down by regulatory authorities in New Zealand and in importing countries overseas. Under New Zealand's Resource Management Act, meat companies have a duty to avoid, remedy or mitigate any adverse effects on the environment arising from their activities.

Thirdly, commercial retailers are responsible for most of the decisions that determine which display cabinets meat products appear in, and in what volume and form. Being aware of the needs and expectations of their customers, retailers impose their own framework of quality requirements that relate to animal welfare, animal identification, respect for the natural habitat and ecosystems, the integrity of the finished product, packaging, handling methods and truthful labelling.

Under new legislation effective on 1 November 1995, the Animal Products Act, New Zealand meat processors are required to take primary responsibility for the effectiveness of the food safety systems in their plants. The duties of processors are specified more clearly than previously. This will be achieved through "risk management programmes" (RMPs) that companies must prepare, be accountable for and have their safety performance assessed against. The aim of the RMPs is to ensure that only product which is "fit for purpose" is allowed to leave plants. Much heavier penalties than before will apply to breaches of this Act. The New Zealand Government will continue to set food safety standards and be responsible for providing official assurances to importing countries. ◆

The Malaysian oil palm industry: progress towards environmentally sound and sustainable crop production

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Abstract

Socio-economically, the oil palm is a highly important crop in Malaysia. Like the tropical rain forest, it is an efficient sequesterer of atmospheric CO_2. Its thick umbrella-like canopy also provides continuous ground cover which is conducive to long-term soil stability. The palm oil industry has a good track record in regard to environmental protection, including waste management and waste and by-product utilization. It has taken appropriate measures over the years to prevent degradation of soil, air and water. The oil palm is an energy efficient crop. Compared to the other major annual oilseed crops, its cultivation and processing require lower inputs of agrochemicals and fossil fuel to produce a tonne of oil, with fewer resulting emissions.

Resumé

En Malaisie, le palmier est une culture très importante du point de vue socio-économique. Comme la forêt ombrophile tropicale, il est très efficace pour piéger le CO_2 atmosphérique. Son couvert épais en forme de parapluie est également une excellente couverture permanente qui stabilise le sol à long terme. Les professionnels de la culture du palmier ont depuis longtemps une bonne réputation en matière de protection de l'environnement, notamment pour la gestion des déchets, leur valorisation et celle des sous-produits. Au fil des ans, ils ont pris les mesures

Resumen

El cultivo de la palma de aceite tiene una gran importancia socioeconómica para Malasia. Al igual que la vegetación de la selva tropical, es un eficaz captor del CO_2 de la atmósfera. Su tupido penacho en forma de paraguas proporciona asimismo al suelo una protección permanente, lo que le aporta equilibrio a largo plazo. La industria de la palma aceitera tiene un informe muy favorable en lo que concierne al respeto del entorno, incluso en lo tocante a la gestión de desechos y a la revalorización de residuos y derivados. Se han tenido que aplicar medidas preventivas apropiadas durante años para evitar la degradación del suelo, el aire y el agua. Estas palmas constituyen un cultivo rentable en cuanto a la energía. Su cultivo y procesamiento requieren muchos menos productos agroquímicos y combustible mineral para producir una tonelada de aceite que los demás cultivos aceteros anuales a base de semillas y esto resulta en la reducción de las emisiones.

Introduction

From a modest beginning in 1917, the Malaysian oil palm industry has seen unprecedented growth in the last four decades, emerging as the leading agricultural industry in the country. The area under this crop has rapidly increased and presently stands at 3.1 million hectares, accounting for more than 30% of the agricultural land under cultivation. In 1998, Malaysia produced 8.3 million tonnes of palm oil and 1.1 million tonnes of palm kernel oil, equal to 10% of the world's consumption of oils and fats.

The palm oil industry is an important contributor to the country's GDP. Export earnings from palm oil, palm kernel oil and its products in 1998 amounted to US$ 5.6 billion, equivalent to 5.6% of GDP. The crop has also played a significant role in the socio-economic development of rural areas by providing employment and raising the income level. On a national basis, private plantations make up 57% of the 3.6 ha, state-owned government schemes 34.5% and independent smallholders 8.5%.

Of the vegetable oil seed crops, the oil palm is by far the highest yielder, regularly producing 4–5 tonnes of oil per hectare per year, which is eight to ten times more than the yield of soybean. It is also unique in that it produces two distinct oils from one fruit – palm oil from the mesocarp, and palm kernel oil from the kernel. Palm oil is a wholesome and nutritious edible oil. It provides a rich natural source of beta-carotene and vitamin E, two established nutritional anti-oxidants. Together with the kernel oil, it also has a host of non-edible and oleochemical uses.

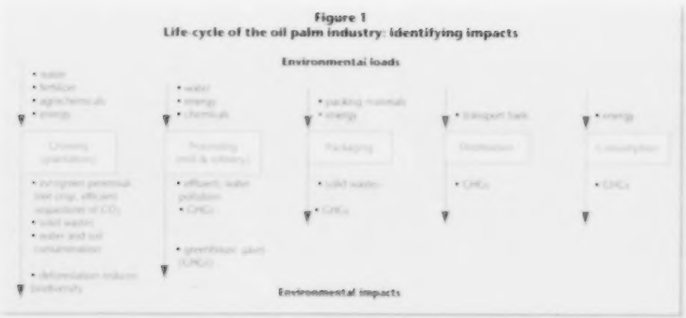
The Malaysian oil palm industry has from the outset placed strong emphasis on research and development on the various aspects of oil palm agronomy and cultivation, sustainable land management, and input resource optimization. It has a good track record on environmental protection, including waste management and by-product utilization. The palm itself, being a perennial tree crop, provides a stable ecosystem, partially emulating the tropical rain forest. Appropriate measures are taken at every stage of crop development, from land preparation and crop establishment right through to processing, to prevent degradation of soil, air and water.

The oil palm and the tropical rain forest

The rain forest of the humid tropics is a unique ecosystem performing numerous complex ecological functions. The area under such forests is gradually being reduced due to human activities. In Malaysia, however, 57% of total land area is still maintained under forest while another 16% is planted with perennial tree crops like oil palm, rubber, coconut and cocoa. These crops are known to partially emulate the rain forest, as they provide continuous cover which favours long-term soil stability. Studies comparing the photosynthetic activity and biomass production of oil palm and a lowland forest in Pasoh, Malaysia, show that oil palm is very efficient as the rain forest in sequestering CO_2 from the atmosphere and utilizing it for growth (**Table 1**; Hartawan 1998).

Studies further indicate that while the rate of dry matter production and biomass accretion is comparable for both systems, the total aboveground standing biomass and carbon stock in oil palm plantations does not approach that of the stable forest due to the limited economic life of oil palms, which are removed and replanted after 25 years. The conversion of forest land for agriculture will remain a sensitive issue. Nevertheless, for developing countries, whose economies depend to a considerable extent on agriculture, it is not totally unavoidable. While appreciating that the rain forest is crucial to the well-being of all life on earth, a balance between development and conservation is needed. It should also be emphasized that the clearing of forest in Malaysia is slowing down, and with it the expansion of the oil palm area.

Figure 1
Life-cycle of the oil palm industry: identifying impacts



Land preparation

In plantings from jungle it is now mandatory to carry out an environmental impact assessment (EIA) when clearing more than 500 ha of inland forest or more than 50 ha of coastal swamps. The study is required to identify all negative environmental impacts the operations will have and the mitigatory measures that need to be taken. The area to be felled is first logged to extract all valuable timber. The remaining trees are then felled, and are useful pieces of wood that can be used in making footbridges (or, in the case of coastal estates with a rail system for fruit transport, railway sleepers) are salvaged. Burning, although

Table 1
Comparison of some physiological parameters of oil palm and tropical rain forest

Parameter	Oil palm (case study)	Rain forest (Pasoh)
Gross assimilation (t CO_2/ha/yr)	161.8	163.5
Total respiration (t CO_2/ha/yr)	96.5	121.1
Net assimilation (t CO_2/ha/yr)	64.2	42.4
Leaf area index	5.6	7.3
Photosynthetic efficiency (%)	1.18	1.71
Radiation conversion efficiency (g/MJ)	1.68	0.86
Standing biomass (t/ha)	100	431
Biomass increment (t)	8.1	5.8
Dry matter production/yr (t)	46.5	25.7

Source: Hoong, 1986

Soil and water conservation measures

Of the 2500 mm of rainfall Malaysia receives annually, 37% is lost through run-off. Substantial amounts of soil and nutrients are lost along with the run-off. Studies with mature oil palm planted on a five to nine degree slope showed that the average run-off was 18.3%, with soil loss amounting to 7.7 tonnes/ha/year. Water management and soil conservation measures aimed at further reducing these losses are therefore essential and are actively practised by most well-managed plantations. On hilly terrain, planting is done on contour terraces which effectively reduce the length of slope and the velocity of run-off. Creeping leguminous cover crops (LCC) are established in the avenues of most new plantings. Besides contributing 18-23 tonnes/ha of dry matter and fixing up to 250 kg N/ha, they help keep out weeds, reduce soil compaction and erosion, and improve rainfall acceptance. Other practices frequently followed include mulching with empty fruit bunches (EFB) and placement of pruned fronds along the contour slope. In coastal plantings, emphasis is given to proper drainage and water management, especially with respect to the fragile acid sulphate and peat soils which, when allowed to overdrain, can deteriorate rapidly.

Upkeep and maintenance

The oil palm has a relatively high nutrient demand. It requires a steady and balanced supply of nutrients for sustained production. Malaysian soils, with the exception of marine alluvial soils, are strongly weathered and incapable of providing only a portion of these requirements; application of fertilizers is therefore necessary. In preparing discriminatory fertilizer recommendations, soil, plant and climate factors are taken into consideration. They include the type of soil and its texture status, the age of the palms and their yield level, leaf nutrient status, agronomic history of the field, fertilizer responses in manurial trials, and rainfall. Further, to maximize fertilizer use efficiency and reduce losses, the choice of nutrient source, placement, timing, frequency of application and supervision are important and are given due emphasis.

Surface run-off of nutrients can be significant on the slopes in high rainfall districts, but it is usually kept at acceptable levels by terracing, silt pitting, grassed cover, mulching, and the wide-spread distribution of the pruned fronds. One study reported annual losses of 13% N, 9% P, 9% K and 16% Mg in mature oil palm on a nine degree slope. Long-term leaching lysimeter studies with mature oil palm on an inland clay loam showed that losses of N, P and K seldom exceed 2.5% of the applied nutrients for the first 10 years.

Figure 2
Life cycle of the oil palm industry: identifying measures

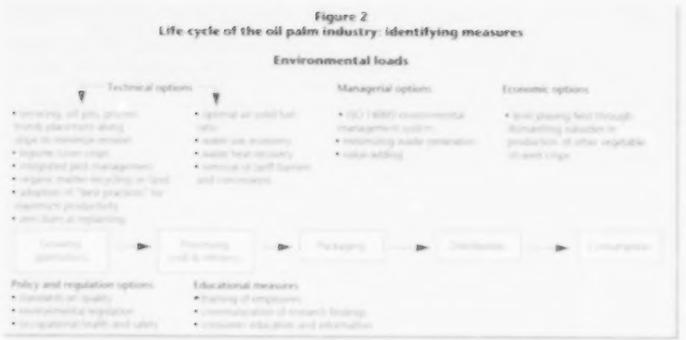

Environmental loads
Technical options:
• spraying, oil pits, process waste treatment along slope to minimize erosion
• legume cover crops
• integrated pest management
• organic matter recycling in land
• adoption of "best practices" for maximum productivity
• zero burn at replanting
• optimal or solid fuel mills
• water use economy
• waste heat recovery
• removal of tariff barriers and restrictions
Managerial options:
• ISO 14000 environmental management system
• minimizing waste generation
• value-adding
Economic options:
• level playing field through dismantling subsidies in production of other vegetable oil seed crops
Growing (plantation)
Processing (mill & refinery)
Packaging
Distribution
Consumption
Policy and regulation options:
• standards on quality
• environmental legislation
• occupational health and safety
Educational measures:
• training of employees
• communication of research findings
• consumer education and information

Table 2
Level of utilization of oil palm biomass residues in Malaysia in 1998 (dry matter basis)

Biomass	Quantity produced (million tonnes)	Quantity utilized (million tonnes)	% utilization	Method of utilization
Pruned fronds	27.20	25.84	95	Mulch
Trunks & fronds at replanting	1.38	1.10	80	Mulch
Fibre	3.56	3.20	90	Fuel
Shell	2.41	2.17	90	Fuel
POME	1.43	0.50	35	Nutrient source & organic fertilizer
EFB	3.38	2.20	65	Mulch & biofuel ash
Total	39.36	35.00		
Level of utilization = 89%				

Plant protection measures

Weed management

A combination of cultural, chemical and, to a lesser extent, biological methods are used for weed control. Cultural practices include ploughing and terracing during land preparation in coastal replants, establishment of LCC to keep out the weeds, and tractor mowing of harvesting paths on flat terrain. Biological control involving the integration of sheep and cattle in oil palm is also an effective method of weed control practised on some estates and by smallholders.

Blanket weeding is discouraged. Soft weeds with a shallow root system which do not grow to excessive heights are encouraged outside the palm circle. Chemical usage is low. Spraying in mature palms is carried out three to four times a year. It is generally confined to the palm circles and a strip of the harvesting path, together representing only about 25-30% of the field area.

Pest management

The major pests of oil palm include bagworms, nettle caterpillars, the rhinoceros beetle, the bunch moth, termites and rats. Insecticides are the most weapon against insect pests, but greater emphasis is now given to integrated control, which involves regular pest monitoring, suitable agronomic practices (including the conservation of beneficial broad-leaf flowering weeds for enhanced parasite and predator activity), establishment of a dense leguminous cover over rotting stumps of the old oil palm stand to prevent breeding of the rhinoceros beetle, conservation and utilization of natural enemies, and judicious use of chemicals. Insecticides with a broad spectrum of activity, long and persistent residues and high mammalian toxicity have been replaced over the years by more target-specific products that are also kinder on the environment. Trunk injection, an environmentally compatible system of treating outbreaks of leaf-eating pests, is now widely practised in the industry, while biological control of rats using the barn owl is also gaining acceptance.

Insecticide use, as in the case of weed control, is small. Apart from the odd generalized outbreak of nettle caterpillars or bagworms, spraying is seldom done over large areas. With regular pest monitoring, outbreaks are detected early, requiring only localized applications of insecticides.

Disease management

Ganoderma basal stem rot and, to a lesser extent, Marasmius bunch rot are the main disease problems in Malaysia. Ganoderma is confined to the replant areas and is managed through cultural practices involving clean clearing (utilization or replanting, removal of diseased palms in existing stand, to prevent secondary spread, and surgery. Marasmius, on the other hand, is a disease of poor palm sanitation. It is usually kept in check by regular pruning and harvesting.

Safety aspects of pesticides

Some modern translocative herbicides with a growth regulator-type activity can cause parthenocarpy and abnormal vegetative growth if drift of the chemical occurs into the crown. For safety, safer-to-use products are avoided in young palm areas or care is taken to ensure that drift onto the palms during spraying does not occur.

Compared to annual crop farming, the quantity of pesticides used in oil palm is low. The new generation of products are also relatively safer and more environmentally friendly. Besides, the tropical climate with its high year-round soil microbial activity should degrade the residues fast, rendering them harmless to the environment.

Safe handling of pesticides, an area of growing concern, is accorded priority and greater emphasis is given to operator safety.

Management and utilization of waste and by-products

Besides the primary products, palm oil and palm kernel oil, the industry also generates a number of by-products and waste materials which are either recycled to the field or converted into value-added products. The main residues produced in the field are the pruned fronds cut during the regular pruning rounds, and the trunks and fronds of the old stand of oil palm at replanting. In the mill the main residues produced during milling of the fruit bunches are palm oil mill effluent (POME), mesocarp fibre, shell, empty fruit bunches (EFB), palm kernel cake (PKC) and bunch ash. The level of utilization of biomass residues in the country in 1998 was estimated at 89% (Table 2).

Organic matter recycling on land

The industry is a strong practitioner of organic matter recycling on land. Apart from the pruned fronds (110.4 tonnes dry matter/ha/year) and the trunks and fronds of the old stand (90 tonnes dry matter/ha), which are regularly recycled, EFB mulching and land application of digested POME is becoming increasingly popular. Mulching the palms with EFB increases yield by up to 75%, while irrigation with digested POME can contribute an additional 12-25% to production (Gurmit Singh, 1994). It is estimated that in 1998, 30 million tonnes of dry matter was recycled on oil palm land with a nutrient value equivalent to 1.96 million tonnes NPKMg fertilizers, worth US$ 255 million (Table 3). In addition, the organic matter recycled returned 13.5 million tonnes of carbon to the soil, increasing its carbon economy. The soil organic C content under mature palms was reported to have increased more than three-fold over a 15-year period, from an average of 0.75% C to 2.52% C.

POME treatment and utilization

POME, a thick colloidal slurry consisting of complex vegetative matter, is a highly polluting material. Its BOD averages 25,000 mg/l, which is 100 times more polluting than domestic sewage. Prior to 1978, the material was discharged untreated into public waterways, adversely affecting aquatic life and water quality. Since then, it is required by law to be treated so as to reduce its BOD to 100 mg/l or less for watercourse discharge and below 5000 mg/l for land application. In 1998, 29 million tonnes of POME was produced by the industry. Through anaerobic-aerobic treatment, the BOD

Table 3
Estimated fertilizer value of oil palm biomass residues recycled on land in Malaysia in 1998

Biomass residues	Method of utilization	Quantity utilized on dry basis (million tonnes)	Fertilizer equivalent ('000 tonnes)				
			Urea	RP	MOP	Kiln	Bunch ash
Trunk and fronds at replanting	Mulch	1.10	13.0	4.0	17.7	8.0	
Pruned fronds	Mulch	25.8	383.0	161.3	692.2	238.0	
EFB	1) Mulch 2) Bunch ash	1.80 0.80	28.4	8.9	67.9	13.9	40.0
Digested POME	Irrigation	0.40	7.0	14.4	30.5	13.1	
Total		29.6	629.4	178.5	808.0	299.4	40.0
Monetary value (US$ million)			84.5	15.5	116.8	36.3	3.5

Total monetary value = US$ 254.6 million

load was reduced by more than 95%.

POME can also be dried, fortified with external nutrients, and made into an organic fertilizer. Several products are now commercially marketed and are proving popular with growers.

Mesocarp fibre and shell as fuel

The mesocarp fibre and shell are used as fuel in the boilers to produce steam and power for various mill operations. The energy generated during the burning of these residues is more than adequate to meet the energy demands of the mill, with some excess electricity available for distribution to the surrounding estate houses, saving the industry in 1998 US$ 51 million in diesel substitution. The residual boiler ash is used for surfacing estate roads. Surplus shell can be used for mulching oil palm seedlings in the nursery, or can be used for the production of activated carbon.

PKC and other residues as animal feed

PKC, a co-product of kernel oil extraction, is a valuable animal feed, the bulk of which is exported to Europe and other countries where it is used as a concentrate feed for feeding dairy cattle. Dried POME, as well as the pulverized fronds and trunk tissues, can also be used as a roughage to feed ruminants.

Lignocellulosic residues as fibre for wood-based industries

The EFB, frond petioles and trunks are a rich source of lignocellulosic fibre, which after separation from the ground parenchyma can be used as raw material for the production of reconstituted panel products such as particle board, medium density fibreboard, cement bonded particle board and gypsum board, or for the production of pulp and paper. Products manufactured using oil palm fibre materials wholly, or in combination with conventional fibres, have satisfactory properties comparable to the other commonly marketed products.

Energy balance

Oil palm is an energy efficient crop. Compared to the other major annual oilseed crops, the cultivation and processing of oil palm requires lower inputs of agrochemicals and fossil fuel to produce any tonne of oil, with lower resultant emissions (Tables 4 and 5). It has a very favourable input-output energy ratio of 9.5, as against 2.5 for soyabean and 3.0 for oilseed rape (Wood and Corley, 1991).

Table 4
Input-output in cultivating oil palm and oil seeds

Item and unit	Inputs per tonne of oil by crop			
	Palm oil	Soyabean oil	Sunflower oil	Rapeseed oil
Seed/fruit for extraction (kg)	4500*	5060	2500	2500
Inputs				
i. Nitrogen (kg N)	47	335	96	99
ii. Phosphate (kg P2O5)	8	77	72	42
iii. Pesticides and herbicides (kg)	2	29	28	11
iv. Others (kg)	88	117	150	124
v. Energy (GJ)	0.5	2.9	0.2	0.7
Outputs				
a) Emission to soil and water				
i. Nitrogen	5	32	10	10
ii. Phosphates	2	23	22	13
iii. Pesticides/herbicides	0.4	23	22	9
b) Emission to air (kg)				
- NO_x	0.5	4	0.3	0.8
- SO_2	0.2	2	0.1	0.2
- CO_2	32	205	16	50
- Pesticides/herbicides	0.1	6	6	2

* Fruit bunches

Source: FAO (1996), as cited from Turkenburgh (1998)

Table 5
Input-output in processing oil palm fruits and oil seeds to vegetable oils and meals

Item and unit		Input-output per tonne of oil			
		Palm oil	Soyabean oil	Sunflower oil	Rapeseed oil
Seed/fruit for extraction (kg)		4500 FFB*	5000	2500	2500
Final product	oil (kg)	1000	1000	400	1000
	meal	200	1500	1500	4000
Input for extraction					
Solvent (Hexane) (kg)		oil	4.1	3.8	3.9
Emission to air (kg)					
- Solvents		oil	4.1	3.8	3.9
- NO_x		-	0.1	0.1	0.1
- SO_2		-	0.2	0.2	0.2
- CO_2		-	56	164	164
Emission to water (kg)					
- COD+		2	Negligible	Negligible	Negligible

* Fruit bunches

Source: FAO (1996), as cited from Turkenburgh (1998)

Notes:
a. A considerable proportion of steam production is from residue of fruits, e.g. fibre and shell.
1. Total is underestimated, as the energy for producing the solvent (Hexane) is not included.
2. COD = Chemical Oxygen Demand.

Life cycle assessment

The life cycle assessment of oil palm, starting from land preparation right through to processing, distribution and consumption, is summarized in **Figures 1 and 2**. The model describes the industry's outputs and outputs, as well as the management tools used to externalize their management.

Conclusion

The Malaysian oil palm industry, as it manifests itself today, is an environment friendly, sustainable, and dynamic, liquid production system. The palm itself is an efficient sequencer of atmospheric CO_2. Compared to the other major annual oilseed crops, it requires less input of fertilizers, pesticides and fuel energy to produce one tonne of oil, generating in the process less emissions and pollutants to contaminate the soil, water and atmosphere. It is an energy efficient crop owing to its input-output energy ratio.

The industry has made considerable progress in managing and utilizing its biomass residues. Several of the residues which, until a few years ago, were discharged as waste or under-utilized are today valuable by-products, directly or indirectly constituting an additional source of revenue. The level of utilization of biomass residues is presently estimated at 89%. Recycling on land is the major component. In 1998 alone, some 11.5 million tonnes of carbon was returned to the soil – a practice that is consistent with the overall concept of sustainable land management.

Yielding up to eight to ten times more oil than the other oilseed crops, and producing at the same time large quantities of lignocellulosic fibre that can be used as an alternative to traditional fibres in wood-based products, cultivation of the oil palm would imply that less forest land needed to be felled to meet growing global demand for vegetable oils and wood.

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Sustainability and the life sciences industry

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Abstract

Biotechnology was billed in the 1980s and early 1990s as the technology to drive a new agricultural revolution. The reinvention of several large chemical companies as "life science" companies was intended to exploit this new knowledge and build on the unfolding genetics revolution. This paradigm shift has begun to develop in certain regions, notably North America, but appears to have come seriously unstuck in others, notably Europe. As with several industries preceding it, the life science industry has failed to integrate stakeholder concerns adequately into their strategic decision-making. This failure, combined with other factors such as a growing mistrust of regulators and of multinational corporations, has meant the new technology has been launched in an increasingly hostile environment.

Resumé

Dans les années 1980 et au début des années 1990, on a vu dans l'arrivée des biotechnologies la promesse d'une nouvelle révolution agricole. En rebaptisant leurs activités « sciences de la vie », plusieurs grands groupes chimiques entendaient exploiter ce nouveau savoir et la révolution génétique naissante. Or, si cette évolution des mentalités a commencé dans certaines régions, notamment en Amérique du Nord, elle semble encore au point mort dans d'autres, notamment en Europe. Comme plusieurs secteurs avant elle, l'industrie des sciences de la vie n'a pas su intégrer les préoccupations des parties prenantes de façon adéquate dans ses décisions stratégiques. Cet échec, combiné à d'autres facteurs tels qu'une méfiance croissante à l'égard des législateurs et des multinationales, a fait que la nouvelle technologie s'est développée dans un environnement de plus en plus hostile.

Resumen

La biotecnología se ha considerado durante la década de los 80 y principios de los 90 la disciplina generadora de una nueva revolución agrícola. La reinstauración de varias grandes empresas químicas en tanto que empresas de «las ciencias de la vida» se produjo a fin de explotar estos nuevos conocimientos y de cimentar la incipiente revolución de la genética. Este giro de paradigmas ha comenzado ya a desarrollarse en ciertas regiones, sobre todo en Norteamérica, mientras en otras, como Europa, ha recibido un serio revés. Al igual que otras industrias que la precedieron, la de las ciencias de la vida no ha tenido en cuenta las inquietudes de los responsables a la hora de concebir su estrategia de desarrollo. Esta lacra, junto con otros factores como la creciente desconfianza de los cuerpos reguladores y las corporaciones multinacionales, influye en el entorno en que se están lanzando las nuevas tecnologías, que resulta cada vez más hostil.

Introduction

At the end of the 1980s, the stratospheric ozone depletion controversy helped define key elements of the sustainability agenda for the 1990s. In very much the same way, the controversy about genetically modified (GM) food has helped map key areas of the political geography over which some of the next decade's great sustainability debates will be fought out. Indeed, no single industry sector of the global economy is as likely to be in the spotlight to such an extent as the economic, social and – above all – ecological impacts of GM technologies are assessed and debated.

None of this should come as a surprise. Some years ago the Environmental Foundation, a UK-based nongovernment established by London's insurance industry in the 1970s, sponsored a two-day consultation on "biotechnology and its potential contributions to sustainable agriculture".[1] The results of this event were highly relevant to the challenges now facing the life sciences sector world-wide, though was that the discussion did not focus on the relevance of environmental (and non-sustainability) concerns. This was taken as read, and instead the focus was on how to address these concerns.

As the Environment Foundation consultation demonstrated, most people agree that any model of sustainable agriculture will need to offer reductions in the environmental burden of agriculture, as well as increased benefits to farmers and improved quality traits for the consumer. Where opinion diverges most dramatically, however, is on how best to achieve this. The life sciences industry, as even a cursory visit to the company web sites demonstrates, argues that agricultural biotechnology has a central part to play in managing this transition.

In its latest sector report for UNEP, SustainAbility is focusing on the sustainability challenges now facing the world's life sciences and genetic engineering (GE) industry. This article draws on early research for the project.

Regional perspectives

Genetic engineering took off in the US in the early 1970s with companies like Biogen, Cetus and Genentech. Early on, some of these companies included agricultural and environmental protection applications in their R&D programmes, but they soon had to throttle back under pressure from financial markets. They focused instead on human health care problems like cancer and heart disease.

At this time, too, the main concerns about the technology were around the accidental release of GMOs from industrial fermenters producing biopharmaceuticals. Since then, the focus has shifted quite considerably to the deliberate release of GMOs as part of GM agriculture. Europeans were the first to voice major concerns about GM foods, with the UK in the forefront, but the protests are spreading to the US with companies like Monsanto now straddling this uncomfortable divide.

North America

By and large, in North America to date the market has proved broadly receptive to the claims of the agricultural biotechnology industry. Public acceptance appears to be high, and market penetration is now approaching 50% for certain crops. Indeed, many of the established environmental NGOs have restricted their calls to demands for stricter controls and more intensive monitoring of GM crops rather than any outright ban.

However, even here, where Roundup Ready soya and other crops have been successful, there is evidence that the greater opposition found from across the Atlantic are beginning to receive greater

credence in the US public sphere.[7] Nonetheless, these protestations are still relatively few and far between, and most would argue that the initial launch of agricultural biotechnology has been largely successful in North America.

Europe

The debate about the role of agricultural biotechnology in Europe was also very neatly confined to the rigour of the testing regime. In 1986, Zeneca had already successfully introduced its GM tomato puree in the UK, and Monsanto was planning its first shipments of GM soya. Monsanto had carried out several stakeholder dialogue sessions in Europe. However, its decision not to segregate the GM soya from traditional varieties, and hence to severely limit the practicality of having access to GM-free sources, was to retrospect the company's greatest error.

For the first time, European NGOs were able to build a strong case against the introduction of GM ingredients that resonated with the European public. The principal focus of this campaign was on "choice", or rather the lack of it provided to European consumers.

A particular strength of the European NGOs' anti-GM campaign has been that it continues to target the same companies that proved so adept at cultivating "chemophobia" in their heartland chemical businesses in the 1970s and 1980s. Initiatives like "Responsible Care" have not fully reassured the public on environmental and health issues, yet "consequently the chemicals/life sciences companies are still not sufficiently trusted to introduce these new and controversial technologies without major challenge."

Abetted by a pervading distrust of multinational corporations in general (and life science companies in particular) and boosted by a lack of confidence in regulators, as well as general concerns about the scale of change, the campaign has grown to dominate the debate about the technology. Newspaper headlines, which initially screamed of the purported dangers of the technology, are now focused on the reactions of other actors such as the investment community, farmers and even the life science companies themselves, who, in the beginning, we are told, to reconsider their involvement in this aspect of the technology.[8]

In less than three years, agricultural biotechnology, "once perceived by the investment community as a bull cow for their 'agricultural' sector, will now be perceived as a pariah."[9] While the public at large, at least in Europe, the industry is now in a position where its license to operate has been almost completely withdrawn and serious questions are also being asked about how to restrict even these rights to terminate in this area.

Other parts of the world

The situation in other parts of the world is still far from clear. Highly vocal protests from farmer groups in India and other parts of Asia, conflict with views of governments' policies that aim to develop free trade in genetically modified seed.

In South America, too, there are conflicting signs as to the likely development of GM agriculture. Nowhere is this clearer than in Brazil, where the federal government has authorized the marketing of several types of genetically modified seeds while the judiciary has passed a resolution covering the entire nation prohibiting the release of GM soya into the environment. Landless rural workers' movements, trade unions, groups of ecologists, and farmers, as well as research centres and women's movements, are demonstrating in Brazil as well as other South American countries such as Paraguay for a suspension of production and marketing of GM crops until further research has been carried out.

In Argentina, meanwhile, and in China the state seems to have succeeded in promoting biotechnology to the farming communities and to consumers. Argentina is now the second largest producer of GM soya world-wide, and China is also reported to be an enthusiastic supporter of the technology – not least as a way of addressing their growing domestic "food gap".

A strategic challenge

Controversies resulting from a failure to fully appreciate the importance of stakeholders in corporate decision-making have long dogged industries such as coal mining, canals, railways, oil, chemicals, nuclear energy and plastics. In many ways agricultural biotechnology is just one, albeit the largest, in this long line of industries under fire.

But there are non-factors at work. Time and again, the evidence demonstrates that it is no longer adequate to rely on the regulatory approval process no matter how rigorous these may be. In the field of European agricultural biotechnology, this is particularly true. The technology has evolved way beyond what regulators can easily understand or address, and such is the pace of development that new legislation is largely defunct by the time it gets implemented.

Furthermore, the public's broader concerns about the relative risks and benefits of the technology, combined with a deep and comprehensive distrust of large multinational companies, has ensured that all forms of biotechnology are likely to be subjected to intrusive and critical scrutiny for the foreseeable future.

The strength of public opinion in Europe and the world was that has now been established should serve to emphasize to the life science industry that any further development of agricultural biotechnology will need to be accompanied by genuine and honest engagement with stakeholders. Fundamentally, companies need to recognize the strategic importance of stakeholder concerns, as well as the need to develop systems for ensuring that such concerns are clearly understood and fully integrated into decision-making at all levels within the industry.

A tool for understanding

In practice, this may mean reviewing how companies evaluate new products and services. Traditionally, the first question that companies have had to answer when developing a new product or service is "Does it actually work". It is at this technical level that much initial research is addressed. Once this has been established, and assuming the answer is positive, there also needs to be an assessment of the extent to which production of the new product or service can be made to be economic, and a reasonable return achieved in the market. Neither of these questions is straightforward, and in the highly sophisticated field of biotechnology both require significant investment. However, even where firm positive outcomes can be achieved with regard to these two questions, additional assessments will need to be undertaken for a successful product or service launch.

This third stage of analysis focuses on the social-political dimension of the new product – and it is at this stage that the company needs to genuinely understand and address the ethical and cultural concerns of relevant stakeholders. This aspect of the assessments process is every bit as important as the other two stages. However, as the controversy surrounding agricultural biotechnology clearly demonstrates, it is one that life science companies have largely failed to address. Indeed, in many ways the social-political evaluation must be considered the most important step, as a failure to recognize the importance of stakeholders in one area of a company's activities can have serious repercussions on overall corporate reputation.

An even more fundamental challenge that companies will have to address as part of the assessment process is to consider the basis used for a product. The 1995 Swedish Ability report "Ethical Investment" (Swedish Ability, 1995) developed a framework for evaluating the ethical dimensions of the sustainability of products and services – and applied it to the dairy hormone bovine somatotropin (BST). Other agricultural applications of biotechnology would likely benefit from a more rigorous application of this and other "moral" tests.

Possible futures

The jury is still out on how the arguments for and against agricultural biotechnology will be resolved in the future. Looking back, there may be lessons and analogies. Comparisons with the nuclear, aerospace and nuclear energy suggest three rather different scenarios with regard to future developments.

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Transgenic plants and food security

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Abstract

To ensure world food security in a sustainable manner, a number of questions related to safety, distribution and other factors must be addressed. However, it should not be forgotten that producing enough food is essential. Food-related world trade issues (including those concerning applications of biotechnology) should be the subject of continuous dialogue among countries and companies. Internationally harmonized quality and safety standards, based on commonly agreed risk assessment procedures, are the soundest basis for such discussions.

Resume

Garantir durablement la sécurité alimentaire dans le monde suppose que soient abordées plusieurs questions touchant à la salubrité de la production alimentaire, à la distribution et à divers autres facteurs. Mais il ne faut pas oublier qu'il est essentiel de produire des denrées alimentaires en quantité suffisante. Les enjeux du commerce international liés à la production alimentaire (notamment aux applications des biotechnologies) doivent faire l'objet d'un dialogue permanent entre pays et groupes agro-alimentaires. Des normes de qualité et de non-dangerosité harmonisées au niveau international et basées sur des procédures d'évaluation des risques reconnues par tous constituent la meilleure base pour ce type de débat.

Resumen

Para garantizar al mundo la seguridad alimentaria de forma sostenible, debemos plantearnos una serie de preguntas relacionadas con la seguridad, la distribución y otros factores afines. No obstante, tampoco debemos olvidar que producir alimentos suficientes es fundamental. Los asuntos relacionados con el comercio mundial de alimentos (entre los que se incluyen los relativos a la biotecnología) deberían seguir protagonizando los debates entre empresas y países. Las normas armonizadas sobre calidad de alcance internacional y basadas en procedimientos de análisis de riesgos de probada eficacia

With the decrease of arable land per capita from 0.3 hectares in 1990 to 0.24 hectares in 2025, according to FAO, we face the challenge of ensuring food security in a sustainable manner. Food security obviously does not depend on food production alone. It also depends heavily on food distribution, linked with poverty alleviation, peace, and several other political and socio-economic factors. Of course a holistic approach is necessary to ensure food security at the world level. However, it is also obvious that food production is a prerequisite.

The ability to produce more and safer food depends on innovation. The development of transgenic plants is a perfect example of innovation in agriculture. How can these plants participate in food security, at the global level? In this article, food security is understood as having three aspects:

- food quantity, provided in a sustainable manner;
- food quality;
- food safety.

Producing enough food sustainably

It is not enough to produce enough food to feed the planet. You still have to do it in a sustainable manner if you want to ensure food security in the long term. It is necessary to implement agricultural systems with the following characteristics:[2]

a) maintenance of the soil while avoiding and/or limiting erosion;

b) maintenance of the soil's fertility level;

c) a high level of productivity, in relation to demand;

d) stability of yield over the years;

e) preservation of biotopes;

f) preservation of water quality;

g) preservation of air quality.

Transgenic crops can have a major impact on the achievement of most of these characteristics, in particular:

Soil maintenance

Many studies, in both developed and developing countries, show that minimum and zero tillage are among the most efficient techniques to limit and/or avoid erosion. However, in minimum and/or zero tillage systems the major limiting factor is weeds. The development of herbicide tolerant varieties is one of the best solutions to overcome this difficulty. Various breeding techniques can lead to such tolerant varieties, from mutation to genetic engineering, via the selection of plants in existing populations. It has been reported, for instance, that use of Round-up Ready™ soya beans in combination with no-till production methods decreased erosion by 90%.[3]

These results are especially important in tropical and continental climates.

Increased productivity

The benefit of "more food" is difficult to sell today in the United States or Europe, in the midst of over-supply and historic low prices. But at the world level we require significantly greater yields than currently available. Biotechnology is an additional tool to achieve this goal. The Rockefeller Foundation has funded Mexican researchers who added genes to rice and corn to increase tolerance to aluminium – a soil toxicity problem that blights vast areas of the tropics. In India, scientists have added two genes to rice that appear to help plants that are submerged for long periods, a common problem in Asia. Drought is a major limiting factor in many parts of the world, and scientists are working on isolating and introducing drought resistance/tolerance genes into crops. There are also some results on frost resistance.

Regarding biotic stress, the development of pest resistant varieties in many crops such as rice, corn (maize), cotton, papaya, sweet potato and vegetables is a reality, allowing either yield improvement or decrease in pesticide use or both.

Most of the work on productivity will also have a positive effect on yield stability.

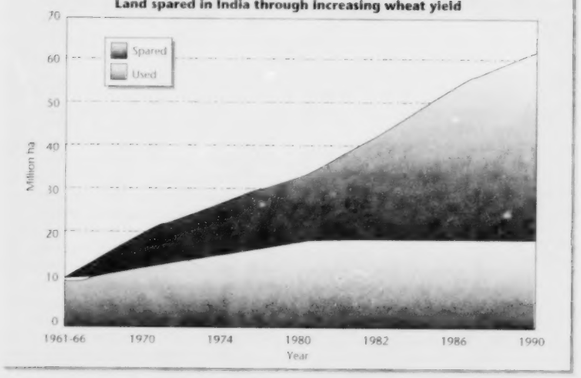
Preserving biotopes

A biotope is a place where a species or a group of species live. Two aspects are important here: protecting wild biotopes, and preserving the fauna in cultivated ones.

The need for more food and fibre to meet the demands of a growing population is a terrible threat to wild areas. Agriculture is now encroaching on forests, swamps and marginal areas to the detriment of global diversity. The only way to avoid an acceleration of this trend is to increase productivity per arable land unit. As indicated above, plant breeding has an essential role to play in reaching this goal. An estimate of wild vegetation maintained in India through development of high yield varieties is presented in **Figure 1**. Of course the Green Revolution has not had only beneficial effects, but preservation of wild areas is a major factor to take into account.

The losses in cultivated biotopes is endangered by pesticide use, which is nevertheless essential to suppress toxins, moulds, bacteria and insects that would otherwise infest our food or poison it, or destroy the food before we could eat it. Losses due to pests and diseases are often evaluated at 15–30% of the crop potential in many areas. FAO (the UN Food and Agriculture Organization) considers that many developing countries will probably have to increase pesticide consumption

Figure 1
Land spared in India through increasing wheat yield



in order to increase agricultural production. To lessen the impact of pesticides on fauna in cultivated biotopes, the integrated pest management (IPM) strategy has been developed since the mid 1960s. IPM is based on safe use of pesticides, crop rotation, biological control, global phytosanitary programmes, and the use of resistant cultivars. When available, these resistant/tolerant cultivars are probably the easiest means of limiting losses.

Of course plant breeding is essential in developing those cultivars. Two main approaches are taken by plant breeders: use of resistance existing in the species or apparented species by intercrossing, and development of transgenic cultivars. The latter approach will certainly become the most important in the future, as it allows development of resistance to diseases for which no natural resistance, or natural resistance easy to work with, is known. For instance, resistance to cucumber mosaic virus has been developed in melon. The use of genes for *Bacillus thuringiensis* (Bt), a naturally occurring pesticide, in cotton is also very efficient. An Australian survey shows that the use of transgenic cotton led to a 16-86% decrease in insecticide use in various products in 1996/97 and 1997/98.

In May 1999, the result of a laboratory study published in *Nature* indicated that larvae fed on milkweed spread with pollen of Bt corn at high doses were dying. This created violent controversy with regard to the new technology. However, we should keep in mind that the study was conducted in a laboratory under conditions that are very unlikely to occur in the wild. Cornell Entomology Professor Anthony M. Shelton, and University of Adelaide (Australia) Professor Richard T. Roush urge that the public not be swayed "by laboratory reports that, when looked at with a critical eye, may not have any reality in the field or even in the laboratory." Shelton and Roush question whether the Cornell monarch butterfly study was realistic. "If I went to a movie and bought a hundred pounds of salted popcorn, because I liked salted popcorn, and then I ate the salted popcorn all at once, I'd probably die. Eating that much salted popcorn simply is not a real-world situation. But if I died, it may be reported that salted popcorn was lethal," Shelton said in a interview. "The same thing holds true for monarch butterflies and pollen. Scientists have a duty to be incredibly responsible for developing realistic studies. Scientists need to make assessments that are pertinent to the real world." To take account of the real world, the study should also have compared the effect of pollen shift with pesticide shift at the same distance of a cultivated field.

Preserving water quality

Overdoses of chemicals, fertilizers and crop protection compounds can remain in the soil and then pollute surface or groundwater through leaching or run-off. The best way to avoid this pollution is to implement IPM systems for pesticides and integrated plant nutrition (IPN) systems for fertilizers. The role of plant breeding in improving the situation with regard to fertilizers is probably minimal, although the development of cultivars with better root systems is an interesting solution. Plant breeding also has a major role to play in developing herbicide tolerant cultivars, allowing the use of such environment-friendly products as glyfosate or glyfosinolate, which are quickly broken down in the soil and do not move to groundwater. And as already said, herbicide resistant cultivars facilitate no-till cultivation, improving water quality by reducing the amount of sediment reaching the surface water and the concentration of nitrogen leaching through soil to groundwater.

Preserving air quality

The major air pollutants from agricultural production are pesticide shifts, dust and CO_2. As indicated above, breeding pest and disease resistant/tolerant varieties will reduce both pesticide use and pesticide shifts. Continuous no-till farming, facilitated by herbicide tolerant cultivars, can reduce atmospheric dust loading from cropland to near zero. In addition, wide adoption of no-till farming could significantly reduce CO_2 concentrations in the atmosphere. Indeed, no-till soils serve as a "carbon sink" where plants take up and deposit more CO_2 than is given off by the oxidation of soil organic matter.

In conclusion, transgenic crops will certainly have a positive impact on the quantity of food sustainably available in the coming years.

Improving food quality

The perturbing thing about references to food quality is that, more often than not, it is unclear what precisely is meant.[3] However, defining some quality criteria is possible:

- When consumers speak of quality, they are in fact referring to how food looks, feels, tastes or smells, or a combination of sensory or aesthetic qualities.
- Another criterion is food's ability to keep its sensory characteristics and physical qualities under given ambient conditions, or its "shelf life".
- The concept of food's nutritional value is relatively new, but is becoming more and more important. Hence the increased demand for nutritional labelling.

In fact, we have examples of the possible impact of genetic engineering relating to these various criteria:

- The first transgenic plant variety to be marketed was the "flavour-savor" (Flr-svr) tomato in 1994. Its main characteristic was a long shelf life, allowing the harvest of ripened fruits instead of green ones and thus developing a better savour. These tomatoes also have a higher dry matter content, which is appreciated by the food processors.
- In the same domain, the control of ethylene production in the maturing phase has allowed production of melons with better flavour and longer shelf life.
- More recently, a science company has been developing new soya beans. Health benefits are associated with the consumption of soy. Epidemiological data on people from Asian cultures and accumulating evidence from molecular and cellular clinical trials, suggest that isoflavones may confer health benefits related to cardiovascular diseases, cancer, osteoporosis, menopausal symptoms and other diseases.

Soya beans are also a major source of dietary saponins. Many studies show that saponins have the ability to lower cholesterol in blood vessels, inhibit growth of cancer cells, eliminate digestive toxins and strengthen the immune system. However, many people do not enjoy the taste of soy. For others, digestibility can be an issue. A non-genetically enhanced soya bean with high sucrose content has been developed, with 90% less stachyose and raffinose (the two sugars commonly found in soya beans that some people find difficult to digest) than ordinary beans. A genetically enhanced soya bean with high oleic acid content has also been developed. Not only does this bean provide better taste, but it also has a healthier fatty acid profile (high in mono-unsaturated fatty acids). Thanks to genetic engineering, all these traits should be incorporated into the same variety. This should eliminate some of the hurdles to soya bean consumption, allowing more people to include soy in their diet and reap the health benefits.

- A team of scientists at the Swiss Federal Institute of Technology in Zurich and the University of Freiburg have succeeded in inserting seven new genes into rice, developing a new "yellow rice". These genes, which come from different plants and microbial sources, encode enzymes and proteins that give rice the ability to make and store beta carotene in the kernels and allow the kernels to accumulate extra absorbed iron. This is important since, according to the World Health Organization (WHO), between 140 and 250 million pre-school children world-wide are deficient in vitamin A. Improving their vitamin A intake would reduce mortality by 23%, measles mortality by 50% and diarrhea mortality by 33%. It would also reduce the severity of childhood diseases, particularly diarrhea and measles. In addition, iron deficiency, the most important micronutritional shortage that a diet of rice can exacerbate, afflicts more than 3 billion people world-wide. This example shows how biotech will make possible the development of "functional" food.
- Biotechnology also makes possible the development of plants which indirectly have a positive effect on food safety. Plant pathology research has confirmed that corn genetically engineered with Bt genes to protect it from corn borer damage can have significantly lower levels of mycotoxin. Corn borers cause physical damage to the ears, allowing entry of secondary fungal pathogen spores. Their larvae may also carry spores into the ears. These pathogens can then produce toxins within the grain. Studies have shown that a particular mycotoxin, fumonisin, was much lower in the transgenic Bt corn than in regular non-transgenic corn. This effect is due to lowered infection by Fusarium pathogen spores. Fumonisin toxin can accumulate in non-transgenic corn to levels that are highly toxic to horses, and may also affect swine and humans.

Vaccines

The extreme evolution in food quality could be the development of "medicafood". Bacterial infections are the leading causes of infant mortality world-wide, particularly bacteria-related diarrhea in developing countries. Efficacious vaccines against enteric bacteria, such as *S. typhimurium*, *V. cholerae* and *E. coli*, would therefore be of great benefit.

Since the early 1990s, scientists have been working on developing oral vaccines based on food crops with the idea of administering dietary vaccines. Very encouraging results have been obtained in potato. However, due to the fact that potato has to be cooked, with a detrimental effect on thermo-labile toxins, trials have also be made on banana, which is eaten raw and is the world's fourth most important food crop. Some interesting results have been obtained. Results have also been obtained on expression of the hepatitis B surface antigen in tobacco, suggesting that there are no major inherent limitations of transcription or translation of this foreign gene in plants.

All the above mentioned examples show the possibility of adding new beneficial traits to plants. But there are also developments concerned with suppressing unfavourable ones:

- The development of transgenic plants with built-in disease or insect tolerance would allow the reduction or even suppression of the use of pesticides, lowering pesticide residues in crops like potato, corn, squash, etc.
- Mycotoxins (see above) are the toxic products of certain microscopic fungi which, in some circumstances, develop on or in foodstuffs of plant and animal origin. Hundreds of mycotoxins have been identified. They are produced by some 200 varieties of fungi. In terms of implications for human health and the economy, mycotoxins are by far the most important contaminant in the food chain. Recent results suggest that the development of organic agriculture significantly increases the level of mycotoxins in crops, with a possible increase in the population that has been immuno-compromised. Several companies are exploring the use of particular transgenic varieties engineered to degrade mycotoxins.

Allergy

Many foods derived from plants may elicit allergic sensitization in someone in the population. The revised list of foods known to cause hypersensitivity, and which should always be declared when identified, is the following:

- cereals containing gluten and products thereof;
- peanuts, soya beans and products thereof;
- tree nuts and nut products.

Such allergenicity is due to naturally occurring proteins (see below). By shunting the production of the allergenic proteins in the development of a plant, it would be possible to render it non-allergenic. Interesting results are already obtained in cereals, and work is also being developed on other crops.

Assessing food safety

One of the most controversial aspects of transgenic plants, along with environmental safety, is food safety. Many of those opposed to genetically enhanced crops indicate that food safety is not evaluated carefully enough.

In fact, at the very beginning of plant biotechnology in 1983, the Science and Technology Committee of the OECD (Organisation for Economic Cooperation and Development) set up a National Expert Group (NEG) to assess the safety of biotechnology. The NEG decided that priority should be given to food safety. General principles were established, and these were published by OECD in 1993 under the title *Safety Evaluation of Foods Derived from Modern Biotechnology: Concepts and Principles*. This was the first document to use the concept of "substantial equivalence". In 1994, the OECD and WHO organized a meeting devoted to "Applications of the Principles of Substantial Equivalence to the Safety Evaluation of Foods or Food Components from Plants Derived by Modern Biotechnology." Since then, this principle has been used on an international basis to draw up strategies for assessing the safety of novel foods, with some variations from country to country.[4]

In general, two main concerns are expressed regarding transgenic foods: potential allergenicity and the use of antibiotic markers.

The OECD consultations have examined the aspect of allergenicity and defined the criteria that need to be assessed: the molecular weight of the proteins, the amino-acid sequences of the potential allergens, their resistance to heat denaturation and digestion, their level of glycosilation and their abundance. All these criteria are assessed using biochemical analyses and *in vitro* tests in a reconstituted gastric and intestinal environment.

It has been reported that a product at the development stage was found through this procedure to be potentially allergenic, showing that the criteria selected were relevant to the assessment of food safety.

Post-marketing monitoring of transgenic food is also recommended as an efficient way to control food safety. It must be noted that by now transgenic foods have been eaten by hundreds of millions of people in Europe, America and Asia, without any known problem, indicating that the assessment of allergenicity is working satisfactorily.

As regards antibiotic resistance markers, it must be noted that a plant engineered to contain a gene for antibiotic resistance does not make the person who consumes the plant resistant to the antibiotic. It is also important to note that antibiotic resistance genes do not result in antibiotic production in a plant. In other words, no antibiotics are present in foods produced from plants containing these genes, and thus there is no effect on gut microflora.

The next controversial issue is the perceived concern that life-saving antibiotic drugs could be rendered less effective if food containing antibiotic resistance genes were eaten.

What is the likelihood of transfer to human pathogens?

Over the past decade, research has looked at the possibility that antibiotic resistance genes used on markers for genetically engineered plants could be transferred from the plant to bacteria harmful to humans. To date, stable gene transfer of an antibiotic resistance marker from plant genomic DNA to microorganisms has never been shown to occur under natural conditions. This does not preclude the possibility of its happening, as it is impossible to prove the opposite. But the question which follows is: what would be the consequences if that happened?

In fact, the two marker genes used most in plant biotechnology encode resistance to kamanycin and ampicillin. These are old antibiotics whose use in treating disease has decreased as the pathogen strains they used to kill have increasingly acquired natural resistance. Tests show that around 50% of bacteria in the human digestive tract have already acquired resistance to ampicillin. It is the same for kamanycin, to which many bacteria in the digestive tract and in soil are already

resistant. That means that even if a very unlikely transfer from plant to bacteria occurred, it would not have any practical importance.

It is also important to note that, despite three Scientific Committees at European level having completed the safety assessment of a corn containing an amikacin marker and "cleared" the plant, final authorization was not given, as amikacin was a clinically important antibiotic. This decision shows that, in assessing transgenic food safety, there is no place for complacency. Products are assessed on a case-by-case basis according to their safety merits.

Assessing the safety of food produced from transgenic plants is essential. Up to now it has proven efficient. However, food safety assessments must not be used as non-monetary trade barriers by countries when the volume of world trade in food (which, in 1997, already exceeded the value of US$ 380 billion) is steadily growing.[5]

Countries participating in world trade are both importers and exporters. Commercial streams of food will best flow freely if emerging problems are dealt with on the basis of continuous dialogue, and if countries adopt harmonized food quality and food safety standards. That harmonization is to be based on risk assessment, which is primarily a scientific exercise conducted in accordance with internationally recognized rules such as the principles laid down in the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) of the WTO (World Trade Organization).

With the new status given the joint FAO/WHO Codex Alimentarius Commission, which is in charge of defining food standards, the subsidiary and advisory bodies to the Codex form the most relevant forum for a scientific dialogue on the assessment of emerging products. It is interesting to note that the Codex Alimentarius Commission, at its 23rd session in July 1999, decided to establish a Task Force on Food Derived from Biotechnology. That task force should help define and harmonize requirements for assessing the safety of food derived from transgenic plants, thus allowing consumers to reap the benefits of biotechnology world-wide.

Conclusion

Transgenic plants will very likely impact positively on the sustainable production of enough food which is safe and of good quality. The seed industry has already participated in fora with other stakeholders, such as industries, consumers, environmental groups and governments, where public controversies over genetically modified organisms were discussed. It is willing to continue this dialogue openly, particularly through making available the necessary technical information. Very recently, in August 1999, the seed industry established an Initiative on the International Movement of Seed and Biotechnology aimed at defining assessment technology and transferring that technology to third parties. Practical results should be achieved by the end of this year.

* *International Association of Plant Breeders for the Protection of Plant Varieties (ASSINSEL)/ International Seed Trade Association (FIS).*

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De la sécurité alimentaire à l'environnement

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Abstract

The Danone group of companies, a world leader in its main market areas (dairy products, sweet snacks and mineral water), has long had both an active food safety policy and a tradition of environmental protection. This article presents these two linked themes, with an emphasis on Danone's rigorous and consistent strategic approach. Several indicators and examples illustrating this strategy are provided.

Résumé

Le Groupe Danone, numéro 1 ou 2 mondial sur ses métiers prioritaires (produits laitiers frais, biscuits sucrés, eaux minérales) a depuis longtemps une politique active en matière de sécurité alimentaire et une tradition en matière de préservation de l'environnement. Ces deux thèmes, sécurité alimentaire et environnement, qui sont en partie liés, sont traités ci-dessous en insistant sur la rigueur et la continuité de la stratégie. Quelques indicateurs et exemples sont cités pour illustrer cette stratégie.

Resumen

El grupo Danone, líder mundial en sus áreas de negocio principales (productos lácteos frescos, galletas y agua mineral), lleva tiempo desarrollando una política activa en materia de seguridad alimentaria y la habitual protección del medio ambiente. El presente artículo profundiza en ambos temas, que están parcialmente relacionados, y hace hincapié en el rigor y la continuidad de la estrategia. También facilita indicadores y ejemplos para ilustrarla.

La sécurité alimentaire : une exigence sur laquelle les grandes marques ne peuvent transiger

La sécurité alimentaire est l'exigence de base d'un leader de l'industrie alimentaire. Depuis de nombreuses années, le Groupe Danone, numéro 1 ou 2 mondial pour les produits laitiers frais, les biscuits sucrés et eaux minérales, a donc développé une politique volontariste d'identification et de contrôle des points critiques, dans le cadre des exigences de qualité qui sont les siennes. Certains de ces points critiques sont bien identifiés, comme les contaminations bactériologiques. Pour s'en prémunir, les filiales du Groupe ont développé des « systèmes sophistiqués » d'assurance qualité », notamment, dans les procédés de fabrication : mise en place d'autocontrôles, même lorsqu'ils ne sont pas exigés par la réglementation, développement d'une méthode d'identification des phases du cycle de production exigeant un suivi particulier, chartes qualité, etc. Les résultats sont tangibles : aujourd'hui, au sein du Groupe, plus de cent sites industriels (soit près des deux tiers) sont ainsi certifiés selon la norme internationale d'assurance qualité ISO 9002.

La maîtrise des nouveaux éléments critiques

Face à de nouveaux types de risques, le Groupe a par ailleurs suscité la création d'un Pôle de compétences en sécurité des aliments dont la mission est de travailler à l'identification et à l'évaluation de ces éléments critiques ainsi qu'au développement d'outils de traitement.

Dans le même esprit de précaution rigoureuse, le Groupe s'appuie sur des experts scientifiques extérieurs. En 1998, la mission du Conseil scientifique consultatif sur la sécurité des aliments (créé à l'origine pour les activités Epicerie) a été élargie à l'ensemble des activités du Groupe. Dix experts de renommée internationale siègent à ce conseil.

Les organismes génétiquement modifiés

Enfin, au-delà des éléments clairement identifiés ou connus, le Groupe est particulièrement sensible à l'évaluation et au suivi des « risques perçus » par le consommateur dont les organismes génétiquement modifiés (OGM) constituent aujourd'hui l'exemple le plus marquant.

A l'heure actuelle, la recherche et les publications scientifiques n'ont pas mis en évidence que l'utilisation d'OGM devait susciter une inquiétude particulière pour la santé humaine. Néanmoins, pour tenir compte des préoccupations des consommateurs, le Groupe a décidé de maintenir ses efforts pour garantir que les ingrédients issus du soja et du maïs qu'il utilise sont d'origine conventionnelle.

Le Groupe demande donc à tous ses fournisseurs d'ingrédients utilisés pour des produits vendus dans l'Union européenne de certifier qu'ils respectent ces règles et il effectue les audits nécessaires pour s'en assurer.

D'ailleurs, dans le domaine de la détection de l'éventuelle origine OGM des ingrédients utilisés, le Groupe est à la pointe en Europe. Il est aujourd'hui l'un des premiers industriels capables non seulement de détecter mais aussi de quantifier la présence d'ADN génétiquement modifié, grâce au Tepral, l'un de ses centres de recherche.

La stratégie environnementale du Groupe Danone

La qualité des produits Danone dépend de la qualité des matières premières utilisées. Or, la qualité du lait, des céréales, des fruits... dépend in fine de la qualité de l'eau, de l'air et des sols. Ce lien simple suffit à expliquer pourquoi le Groupe Danone a mis en œuvre très tôt une politique en matière d'environnement. En 1996, le Groupe a formalisé cet engagement dans une Charte pour l'Environnement. A travers cette Charte, il s'est engagé dans une démarche :

- **globale**, car elle concerne l'ensemble des activités du Groupe, de la conception des produits à leur fin de vie ;
- **exigeante**, car elle demande l'engagement de chacun et cherche à promouvoir les initiatives individuelles ;
- **internationale**, car le Groupe veille à ce que les exigences définies au niveau du Groupe soient appliquées dans toutes les filiales, quelle que soit leur taille ou leur implantation géographique.

La Brasserie Kronenbourg d'Obernai certifiée ISO 14 001 : premier bilan

Les premiers plans d'action définis ont concerné la mise en conformité et en sécurité du site et surtout l'amélioration des performances environnementales : diminution de 20 % de la demande chimique en oxygène (DCO) soit 0,62 kg de DCO/hl bière en 1998 contre 0,78 en 1997, avec une incidence sur la quantité de boues générées lors du traitement des effluents : 7950 t de boues en 1998 contre 9 100 t en 1997, une réduction de 12,5 %.

L'implication du personnel dans le système de management environnemental a redynamisé le tri des déchets à la source : quantité de déchets industriels banals non valorisés réduite de 1518 t au cumul en 1997 à 1081 t en 1998, avec une prévision pour 1999 à 830 t, soit une économie de près de 720 000 FF sur 2 ans. Une nouvelle plate-forme de gestion des déchets a été construite en 1999.

D'autres plans d'action sur la consommation et l'utilisation de l'eau dans le procédé ainsi qu'une opération « chasse aux fuites » sur l'ensemble de l'usine pour l'eau, l'air comprimé et la vapeur ont été engagés.

Le gain a été estimé à 1 500 000 FF pour la première année (hors gain d'énergie).

L'énergie électrique stabilisée à 40 kwPCI/hl en 1997 est tombée à 37 kwPCI/hl en deux ans, soit une économie pour l'usine de 1mFF/an.

Exemple d'indicateurs : produits frais européens (par tonne de produits finis)

	1990	1998	Variation 98/90
Consommation de combustibles kWh/t	600	415	31 %
Consommation d'électricité kWh/t	273	202	26 %
Consommation d'eau m³/t	9,5	7,2	24 %

chaque société respecte les réglementations locales, ou à défaut, fixe ses objectifs sur la base des règlements européens.

Les enjeux

En comparaison avec d'autres activités, l'industrie agro-alimentaire a des conséquences relativement limitées sur l'environnement, puisque la plupart de ses effluents sont biodégradables. Toutefois, cela n'empêche pas qu'il soit nécessaire :

- d'assurer la conformité réglementaire et la maîtrise des risques ;
- de réduire les consommations d'eau et d'énergie, et de limiter les rejets et la production de déchets ;
- d'associer nos fournisseurs dans notre démarche de respect de l'environnement.

Pour faire face à ces enjeux, le Groupe Danone a adopté une démarche qui fait appel de manière privilégiée à la prévention, à la sensibilisation, à la formation du personnel, mais aussi au suivi d'indicateurs et à la certification environnementale.

Les priorités du Groupe Danone

Afin de limiter l'impact de ses activités sur l'environnement, le Groupe met en œuvre une politique basée sur 3 axes prioritaires :

• Des usines qui respectent leur environnement

Au delà du minimum que représente la mise en conformité réglementaire de ses usines, le Groupe s'efforce de faire appliquer à l'ensemble de ses sites un principe simple : « usine sobre, usine propre ». Pour évaluer et réduire les consommations d'eau, d'énergie et la production de déchets, des outils de management environnemental (auto-diagnostic, audits, indicateurs, ISO 14001...) ont été mis à la disposition de l'ensemble des sites.

La démarche de certification ISO 14001 n'a aucun caractère obligatoire, mais elle s'étend rapidement. En septembre 1999, une douzaine de sites du Groupe sont certifiés ISO 14001.

• La réduction des impacts des emballages sur l'environnement

En continuité avec la création d'Eco-emballages, le Groupe participe activement aux différentes organisations qui s'occupent dans les pays étrangers de la fin de vie des emballages (organismes « point vert »).

Au titre des actions de prévention, un « guide de conception écologique des produits » a été diffusé en 1998. Il demande la minimisation du poids des emballages, ainsi qu'un choix de matériaux rationnel du point de vue écologique et économique et tenant compte de la fin de vie des emballages.

• La promotion de l'agriculture raisonnée

Pour répondre aux souhaits des consommateurs, qui veulent acheter des produits sains, ayant du goût et provenant d'une agriculture qui ne pollue pas, le Groupe Danone encourage par ses achats les agriculteurs à pratiquer une agriculture plus raisonnée. Il s'agit d'une agriculture qui, tout en restant compétitive, prend en compte les objectifs de qualité des produits et le respect de l'environnement. En clair, l'agriculture raisonnée renonce à l'usage systématique des traitements chimiques et des engrais au profit d'une utilisation plus limitée et plus ciblée : « la juste dose au bon moment ».

Selon nous, l'agriculture raisonnée devrait être généralisée, l'agriculture biologique ne pouvant constituer une solution globale aux problèmes alimentaires. Ce concept intéressant de plus en plus les agriculteurs, les industriels et les distributeurs, il serait souhaitable de parvenir à une définition commune des principes et pratiques auxquels il fait appel, afin d'assurer de manière pérenne sa reconnaissance par le consommateur.

Kronenbourg a ainsi mis en place dès 1986 un cahier des charges pour l'orge de brasserie, qui visait à limiter l'usage des engrais azotés. Concernant le lait, une Charte Sécurité – Qualité du Lait Danone a été instaurée en 1992, afin de garantir le respect de certaines exigences quant à l'élevage et à la qualité du lait. Un document Qualité – sécurité du lait est désormais appliqué dans toute l'Europe.

Ces actions qui visaient principalement à la sécurité des produits tendent à l'heure actuelle à s'inscrire progressivement dans une démarche plus globale d'agriculture raisonnée.

Soucieux de réconcilier le consommateur avec la filière agro-alimentaire, le Groupe a établi un partenariat de 3 ans avec les jeunes agriculteurs, des industriels et des distributeurs pour communiquer de « la fourche à la fourchette » sur la nécessité d'une agriculture raisonnée et durable, dans le cadre d'une opération intitulée Terre Attitude.

Exemple d'indicateurs : activité brassicole en Europe (par hl de bière)

	1990	1998	Variation 98/90
Consommation de combustibles kWh/hl	45,0	35,0	22 %
Consommation d'électricité kWh/hl	12,1	11,3	7 %
Consommation d'eau m³/hl	10,0	6,3	37 %

Le document Qualité – sécurité du lait

Depuis 2 ans, les agents « relations culture » de Danone France passent dans toutes les exploitations laitières qui livrent régulièrement nos usines. Ils vérifient une vingtaine de points de conformité concernant le suivi des animaux, les règles sanitaires : l'alimentation, les soins des animaux et la traite. Cette procédure, initiée en France, est en cours d'extension aux autres pays. Elle complète les analyses qui sont systématiquement pratiquées sur le lait. Elle illustre le renforcement de la traçabilité et la mise en place d'une assurance qualité à l'amont des usines du Groupe.

L'agriculture raisonnée appliquée aux céréales

En 1999, l'Institut Technique des Céréales et Fromages a établi, en relation avec les producteurs et les transformateurs, un guide de production raisonnée pour le blé tendre. Ce guide sera mis en œuvre à titre expérimental, au cours de la campagne 1999-2000, en vue d'une extension lors des campagnes suivantes. Le Groupe Danone apporte son appui à ce programme par sa participation au Comité de pilotage et par l'intermédiaire des achats de la branche biscuits.

Conclusion

La stratégie environnementale du Groupe Danone s'inscrit désormais dans le mouvement mondial en faveur du développement durable et dans une politique de responsabilité sociale. Les progrès accomplis dans ce domaine situent le Groupe en bonne position parmi les entreprises agro-alimentaires.

Cependant nous avons aussi conscience du chemin qu'il reste à parcourir pour répondre à l'attente de plus en plus exigeante du consommateur et du citoyen. L'environnement nécessite des efforts constants en matière d'investissements matériels et humains et une vigilance permanente. Sa prise en compte doit être de plus en plus globale, avec une attention particulière à apporter désormais à la partie amont du cycle de vie du produit, celle de la production agricole. ◆

La réduction des impacts des emballages sur l'environnement

La bouteille d'Evian 1,5 litre PET compactable

Le changement de la nouvelle bouteille d'eau minérale d'1,5 l (36g au lieu de 42g) a permis une économie de 14 % de matière plastique (3740 t de réductions annuelles sur le marché français). De plus, la nouvelle conception permet le compactage de la bouteille après consommation. Ainsi compactée, la bouteille occupe un volume quatre fois moindre et contribue à la réduction du volume des déchets ménagers.

Réduction à la source : l'emballage du yaourt

Danone France vend chaque année des milliards de pots de yaourt.
De 1996 à 1998 :

- Le poids du plastique du pot a diminué de 6 %.
- Le poids des plateaux de transport en carton a diminué de 9 %.
- Le taux de produit recyclé inclus dans les cartons a sensiblement augmenté (55 % pour les cartons de regroupement, presque 100 % pour les plateaux de transport).

How to make agri-food supply chains sustainable: a multinational's perspective

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Introduction to Unilever

Unilever is a multinational company, producing branded fast-moving consumer goods in foods and home and personal care products. Unilever foods represents somewhat over 50% of the business. Agriculture (including animal husbandry and fisheries) provides an estimated two-thirds of all Unilever raw materials.

Unilever and sustainable development

Unilever's view is that it is not sufficient to make good and safe products, and to market them successfully. We believe we should also seek actively to align economic, environmental and social objectives right along our supply chain. Our purpose – to meet the everyday needs of people everywhere – also means for us ensuring that the raw materials we use remain available for the indefinite future. Another consequence is that we seek to satisfy consumer expectations in terms of the nature and origin of our raw materials.

Through the Unilever environmental programme, we run a number of initiatives on product improvement and process control in the supply chain. In addition, Unilever has embarked on three sustainable development initiatives in regard to fisheries, water stewardship and agriculture. This article provides the background to Unilever's contribution to sustainable agriculture.

Sustainable agriculture: key requirements

According to our definition of sustainable agriculture, land is managed so as to guarantee ongoing high yields of agricultural produce over time, while minimizing inputs and costs in terms of fossil energy, fertilizers, pesticides, herbicides or other auxiliaries. It is not sustainable, using this definition to keep yields high by continuously increasing inputs into the process while eroding the inherent productivity of the soil. Nor is it sustainable to try and maintain agriculture solely on the basis of subsidies. Competitiveness should be proven through free marketplace pricing.

In practice, a complex set of criteria will have to be met:

- Output must be high enough;
- Negative environmental impacts on soil, air, water and biodiversity must be minimized;
- The quality and safety of products must be guaranteed;
- Changing consumer demands must be met;
- Profitability must be competitive with that of other industry sectors;
- Agriculture must offer an attractive livelihood to workers.

Although stakeholders' views vary, the following goals, described by Professor Jules Pretty of the University of Essex (author of *Regenerating Agriculture*), summarize the prevailing views on how to meet these criteria:

- maximizing the incorporation of natural processes such as nutrient recycling, nitrogen fixing, and pest-predator relationships;
- minimizing the use of external and non-renewable inputs that damage the environment or harm the health of farmers and consumers;
- participation of farmers and rural communities in the processes of problem analysis and technology development, adaptation and extension;
- more equitable access to productive resources and opportunities;
- greater productive use of local knowledge, practices and resources;
- increased self-reliance among farmers and rural communities;
- an emphasis on building strong rural social organizations and dynamic rural economies.

Obviously, this suggests a significant move away from the priciples of so-called "intensive" agriculture, but we believe it is also different from, and in certain respects more comprehensive than, so-called "organic" farming. The emphasis is on a total systems approach to sustainable production, based on rational analysis and validated assumptions. All this needs to be achieved while meeting the nutritional needs of a growing world population that enjoys increasing disposable incomes.

The challenge in sustainable agriculture is to combine the latest scientific views on all aspects of agronomy with empirical, sometimes traditional knowledge on pest management, crop rotation, etc. This body of knowledge needs to be developed and brought to the rural community through participative learning, involving the people concerned. In this way the learning process itself (which will have to continue once outside involvement has stopped) will be sustained. It is not Unilever's aim to make suppliers dependent (i.e. on Unilever's input of knowledge and expertise), but on the contrary to support them in setting up consulting mechanisms aimed at finding solutions.

Unilever's contribution

For a number of years Unilever has been involved in the development of agricultural best practice for several crops including vegetables, tomatoes, oil palm and tea. Vegetables and tomatoes are being grown by farmers under contract for Unilever. Oil palm and tea are grown on Unilever-owned plantations (although not all the volume needed by Unilever comes from these sources: the remainder is bought on the open market). All Unilever's future activities in this area will build on the experience gained with these crops. In 1995, Unilever commissioned two studies in relation to sustainable development.

One was a study concerning external stakeholder perspectives on sustainable agriculture. Various people from all walks of life were asked what they thought sustainable agriculture should be, and what role a company like Unilever could play in that regard. The second study looked into existing reports on Sustainability Indicators. It selected a group of indicators that were supposed to be relevant to Unilever, measurable by Unilever, and within its range of control. Based on the outcome of these studies, the Unilever sustainable agriculture initiative was shaped in a workshop held in 1998.

Developing our sustainable agriculture indicators

Building on our external consultation, Unilever conducted a workshop with people from inside the company and from NGOs, as well as agriculture experts, to agree on the sort of parameters to be used in defining and monitoring progress towards sustainable agriculture. The outcome is a set of generic indicators which can be refined and tailored to address the characteristics of different crops and the particular local environmental in which they are grown. In selecting indicators, priority has been given to understanding ecological sustainability in agriculture. We believe that without this foundation we cannot meaningfully address social and economic factors.

Soil fertility/health

Soil is fundamental to agricultural systems, and a rich soil ecosystem contributes to crop and livestock performance. Sustainable agricultural practices can improve beneficial components of the soil's ecosystem. Typical parameters: number of beneficial organisms, soil organic carbon.

Soil loss

Soil eroded by water and wind can lose both structure and organic matter, thus diminishing the assets of an agricultural system. Sustainable agricultural practices can reduce soil erosion. Typical parameters: soil cover index, soil erosion.

Nutrients

Crops and livestock need a balance of nutrients. Some of these can be obtained locally (e.g. nitrogen) and some must be imported. Nutrients are lost through cropping, erosion and atmospheric emissions. Sustainable agricultural practices can enhance locally produced nutrients and reduce losses. Typical parameters: amount of inorganic nitrogen/phosphorus/potassium applied, balance of N/P/K over crop rotations.

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Pest management
When pesticides are applied to crops or livestock, a small but significant proportion can escape to water and air, kill beneficial or non-target wildlife, or accumulate in foods, thus affecting human health and ecosystems. Sustainable agricultural practices can substitute natural controls for some pesticides, reducing dependence on externally introduced substances. Typical parameters: amount and type of pesticides (active ingredient) applied.

Biodiversity
Agriculture has shaped most ecosystems in the world, and biodiversity can be improved or reduced by agricultural practices. Some biodiversity is highly beneficial for agriculture. Sustainable agricultural practices can improve biodiversity – both by "greening the middle" of fields and by "greening the edge". Typical parameters: level of biodiversity on-site, habitat for natural predator systems, cross-boundary effects.

Product value
Product value is a measure of the desired outputs of an agricultural system. Sustainable agricultural practices should be able to maintain or improve product value. Typical parameters: total value of produce per hectare, nutritional value (including minerals), ratio of solid waste reused/recycled over that disposed to landfill.

Energy
Although the energy of sunlight is a fundamental input to agriculture, the energy balance of agricultural systems depends on the additional energy supplied from non-renewable sources. Sustainable agricultural practices can improve the energy balance and ensure that it remains positive – i.e. that there is more energy coming out than going in. Typical parameters: total energy input/total energy output, ratio renewable over non-renewable energy inputs.

Water
Some agricultural systems make use of irrigation water, while others pollute or contaminate surface or groundwater with pesticides, nutrients or soil. Sustainable agricultural practices can make targeted use of any inputs, and so reduce losses. Typical parameters: amount of water used, leaching and runoff of N/P/K to surface and groundwater.

Social/human capital
Finding ways to ensure that we use natural resources sustainably requires initiatives in the social sphere, such as collective action, the sharing of new knowledge, and continuous innovation. Sustainable agricultural practices can improve both social and human capital in order to ensure normal outputs. The prime responsibility for this should remain with the local community, leading to realistic targets that can be acted upon. Typical parameters: group dynamics/organizational density of rural community, rate of innovation.

Local economy
Agricultural inputs (goods, labour, services) can be sourced from many places. When they come from the local economy, however, the expenditure helps sustain local businesses and livelihoods. Sustainable agricultural practices can help make the best use of local and available resources in order to increase efficiency. Typical parameters: amount of money/profit spent reinvested locally, employment level in local community.

Current state of affairs
Unilever has initiated pilot projects on a limited number of crops (peas, spinach, tea, oil palm, tomatoes, sunflower, rape seed). These projects have begun, or will soon begin, in Australia, Brazil, France, Germany, Hungary, Kenya, Malaysia, Poland and the UK. The criteria for choosing these crops were their strategic importance to Unilever, and the level of knowledge and control in Unilever.

Further developments
This process could eventually lead to the definition of standards for sustainable agriculture. Unilever would welcome a recognized position in the market for "sustainable agriculture"; that is, mainstream agriculture, using proven technologies, which tries to align economic principles with environmental protection and social progress. Indicator measurement results could serve to make this process transparent. Such standards for sustainable agriculture would need endorsement by a wide variety of experts and stakeholders, e.g. organizations such as FAO, the World Bank, UNEP, NGOs, etc. Market mechanisms could be developed on the basis of such standards (e.g. through certification schemes), to allow raw material buyers and consumers to express their preferences In the long run, our agricultural sourcing policies could be based on such standards.

A sustainable food supply chain

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Abstract
Will meeting eco-efficiency targets be possible with regard to the food supply chain? Much can be done, and there are many "win-win" solutions that would be good for the environment and profitable for individual companies. Examples are given of the changes/measures required in order to make a more sustainable food chain possible. A drastic restructuring of the agriculture and food products industries has occurred during the last 25 years, suggesting that extensive changes could again take place within a relatively short period of time.

Résumé
Sera-t-il possible d'atteindre les objectifs d'efficacité écologique sur le plan de la production alimentaire ? Les possibilités et solutions gagnantes sont nombreuses, bénéfiques à la fois pour l'environnement et pour les entreprises agro-alimentaires. L'article donne des exemples des changements et mesures nécessaires pour rendre plus viable la filière de la production alimentaire. En 25 ans, l'agriculture et l'industrie agro-alimentaire ont subi une restructuration radicale qui laisse présager dans un avenir relativement proche de nouveaux bouleversements à grande échelle.

Resumen
¿Lograremos alcanzar las metas de «ecoeficiencia» en lo relativo a la cadena de provision de alimentos? Aún se puede lograr mucho y existen multitud de soluciones de valor seguro, respetuosas con el entorno y positivas individualmente para las empresas. Se facilitan ejemplos de los cambios y las medidas a tomar para hacer realidad una cadena alimentaria más sostenible. Durante los últimos 25 años se ha llevado a cabo una reestructuración drástica de la agricultura y la industria de los productos alimentarios, lo que sugiere que en un plazo relativamente breve podrían producirse cambios profundos.

Introduction
In view of global environmental challenges, there is an urgent need for instruments that translate sustainability requirements into working targets. To illustrate this need, and to make it understandable, researchers at the Wuppertal Institute in Germany launched the concepts of "factor 4" and "factor 10" during the 1990s to express the efficiency with which we use resources such as energy and materials to meet human needs. In short, we need to use energy and materials between four and ten times more efficiently than we do today to achieve sustainability in the near future. Together with "eco-efficiency", use of the terms "factor 4" and "factor 10" is becoming widespread internationally. They are being used by researchers, politicians and representatives of industry.

A number of recent studies have focused on sustainability aspects of the food supply chain. It should be emphasized that the studies on which this article is based are explorative. They illuminate certain possibilities with regard to increasing eco-efficiency in the food supply chain and moving towards sustainability.

***Sweden in the Year 2021* – a future study**
What does sustainable development mean in concrete terms? In what ways must society change in order to reach that goal? To find the answers, the Swedish Environmental Protection Agency initiated the study *Sweden in the Year 2021*. This study was conducted over four years in close cooperation with the scientific society and other governmental agencies, as well as representatives of the agricultural, forestry, transportation and other sectors. The study's temporal perspective is roughly 25 years.

Within this project, the food supply chain was examined in a specifically food-related study and an agricultural study. Two alternative strategies were chosen, representing the extremes of *large-scale efficiency* (large supply areas, large-scale food products industry, more ready-made food products) and *small-scale local production* (small supply areas, local production, more home-made food). The results indicate that the best alternative for providing food products on a sustainable basis consists of a carefully weighed combination of elements from both these models.

A vision of how a sustainable, eco-efficient food supply chain might look in one generation, worked out during the project, is described later in this article.

The food supply chain today
The food sector is a complex system with many processing stages, including primary gathering from nature and the advanced food manufacturing industry. Long transport distances are sometimes involved. The main players in the food sector, from where the food originates to the final products, can be described as follows:

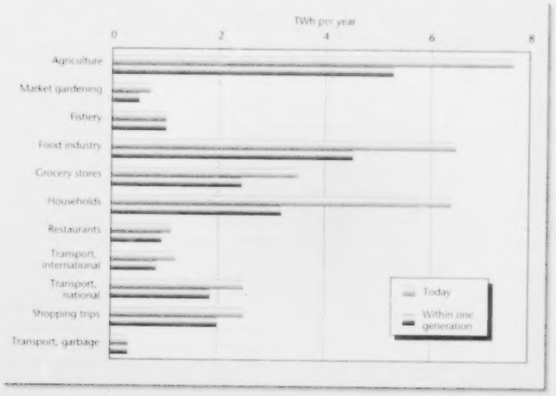
- *primary production*: agriculture, gardening, fishing;
- *refining*: the food industry and its different branches;
- *the trade sector*: wholesalers and retailers;
- *large-scale households*: hospitals, schools, restaurants, etc.
- *consumers*;
- *international players*.

Agriculture – farming and food products
Let us take a glance at the past to get some idea of how agriculture and the entire food supply chain have developed in Sweden from the beginning of the 1970s to the present. There has been a very large increase in farm yields. Total milk production, for example, has increased by 50% since 1970. While there have been large increases in grain productivity, the number of farms has decreased considerably and many hectares of cropland and grazing land have been taken out of production. Since the habitats of many threatened species are associated with grazing land, this constitutes a serious *threat to biodiversity*.

There have also been major changes at the next stage of the food supply chain. The number of dairies, bakeries and distribution centres has declined significantly. From 1969 to 1994, over 80% of Sweden's dairies and distribution centres shut down. This trend towards centralization and large-scale operations has increased the need for transport. Between 1969 and 1994, the number of lorries more than doubled. Anyone who had predicted such a drastic restructuring of the agriculture and food products industries 25 years ago would hardly had been taken seriously. This demonstrates, however, that very extensive changes can occur within the space of 25 years.

The trade sector
The trade sector comprises both wholesalers and retailers. The increasing trend is that Nordic consumers prefer buying their food at large hypermarkets (supermarkets) rather than small corner shops. A Swedish study has shown that when there is such a hypermarket in the vicinity, almost one-third of the inhabitants in the area will use it as their first choice for shopping. According to the study, these hypermarkets have increased car travel. Another survey shows that car travel for purchasing food went up in a number of Swedish towns by a factor between 10 and when a hypermarket was established in the vicinity. The increase was greater in cases where it was established far from an urban area.

Figure 1
First estimate: using already available technology, and with slight organizational and behavioural changes, energy savings of more than one-third can be achieved



The food supply chain's energy consumption today and in 2030. A rough estimate assuming technology that is available today, and minor changes in individuals' behaviour and the organization of food flows. Same food consumption and coverage areas as today. The following assumptions are behind the estimated saving potential:

In *agriculture*, a combination of developed forms of environmentally compatible conventional and ecological agriculture. In *market gardening*, it is assumed that all greenhouses will be 30% more efficient using technology which is already available today.

The energy saving potential of the food industry (30%)has been established through eco-efficiency measures using today's best available technology.

For *haulage*, the potential is assumed to be 30% for international haulage and 25% for long-distance national haulage. Behind these potentials lies the assumption of today's best available technology. With reduced speeds for long-distance haulage and a coordinated distribution system to the shops, more potential is available.

For *the trade sector*, it is assumed that a potential of about 30% could be achieved on heating and lighting and, to a certain extent, also on cooling. If there is a technological breakthrough in the field of refrigerated display counters, another 0.5 TWh could be saved.

For *large-scale households*, the potential is estimated at 15% through increased energy-efficiency.

In *households*, the energy saving potential is estimated at 50%. The most important measures are replacing old refrigerators and freezers with more energy-efficient models when the time for replacement comes.

For *transporting goods to the home*, it is assumed that 20% fewer consumers will choose to use their car for shopping trips.

Fishery and *waste product transportation* has not been studied in detail. It is therefore assumed that energy consumption here will be on the same level as today.

Large-scale households

About 1.2 billion meals are served each year in Swedish large-scale households (hospitals, schools, day care centres, restaurants, etc.), which is equivalent to one-fifth of the total consumption of food in Sweden. The distribution between the private and the public sector is approximately 50-50. Large-scale households are especially important because their bulk purchasing power gives them influence over producers.

Food consumption

Consumers' ability to influence the development of agriculture via the marketplace depends on the kind of information they receive concerning the environmental impact of food products. It is therefore important to improve environmental labelling, so that the consumers may play their proper role in the promotion of sustainable agriculture. At the same time, environmental management and certification must be further developed within agriculture and the food products industry.

What is the problem?

Agriculture

Swedish agriculture today is very efficient, producing food products of high quality. However, it also gives rise to a number of environmental problems.

During food production, artificial *fertilizer* containing both phosphorous and nitrogen is used. Sweden uses less fertilizer than the EU average, but more nitrogen fertilizer than the OECD average. Total use of phosphorous fertilizer in Sweden has decreased by a factor 4 during the past 25 years. When nitrogen and phosphorous leach from cropland into rivers, lakes and the sea, those water resources may fill with vegetation; all life on the sea bed may be wiped out due to eutrophication. In addition, phosphorous is an irreplaceable resource that is essential to life. It should therefore be used sparingly.

Sweden uses less *pesticides* on average than the rest of Europe. Pesticide residues are in general lower in Swedish vegetables than imported ones Total use of pesticides in Sweden (calculated as active substance) has decreased by a factor 3 since the beginning of the 1980s. Use of herbicides and pesticides involves risk to the health of plants, humans and other animals.

Agriculture is also a *heavy consumer of energy* for the operation of farm equipment and the manufacture of commercial fertilizer, all of which adds to CO_2 emissions.

The food supply chain

The food supply chain involves a complex series of production stages and means of transport. The raw material of the food products is provided by agriculture, commercial gardens and fishing. After processing in one or more steps, the finished products are distributed to consumers.

Almost one-fifth of the energy produced in Sweden is used for food supply; about half comes from fossil fuel, which when combusted produces large amounts of climate-influencing gases and other air pollutants. These emissions contribute to global warming, acidification and eutrophication and cause health problems. Almost as much energy is used by consumers taking their food and other consumables home as is used in all transport stages between farm, food industry and shops. Roughly one-fifth of all products from commercial gardens are grown in heated greenhouses, which account for four-fifths of the energy used in these gardens.

A vision of the food supply chain

In the earlier mentioned Swedish future study, a scenario was worked out as an example of how a sustainable and eco-efficient food supply chain could look in one generation. It includes the following elements.

An important change that will have taken place by 2030 is that *energy consumption* within the food supply chain will have become more efficient by at least one-third compared to the 1990s. The greatest energy savings will have been made in households and in the trade sector. In households, although it is primarily a question of more energy-efficient large appliances and alternative storage methods, food will also be prepared using energy-saving techniques. Within the trade sector, efficiency gains will save one-third of the energy.

Food haulage will have developed in terms of both energy consumption and air emissions. Trains will be used where possible. Lorries will generally be much more fuel-efficient and of the highest environmental class. Food haulage to shops will be well-coordinated.

Production of foodstuffs will take place closer to the consumer, reducing long-distance transportation. Since there is no clear proof that domestic or locally produced food is always more environmentally acceptable, holistic analyses will be carried out to consider not only transportation but also processing and agricultural methods.

In all the links of the food supply chain, *wastage* will have been reduced and the food waste that nevertheless remains will be sorted at source.

Agriculture will supply, industry will process, and the consumer will demand environmentally compatible foodstuffs. The *trade sector* will play a key role by ordering and displaying commodities that are environmentally acceptable.

Changes that lead to greater eco-efficiency in terms of energy use, pesticides and fertilizers

Greater eco-efficiency in terms of *energy* will reduce the food supply chain's use of fossil energy. This can be effected in two ways:

- by choosing a renewable energy source, for example through agriculture producing not just foodstuffs but also large quantities of bio-fuel that can replace fossil fuels;
- by using energy more efficiently.

More efficient use of energy: conclusions

There is ample opportunity to make the food supply chain's use of energy more efficient. In an attempt to calculate the potential for using energy more efficiently, two estimates are presented:

- The first estimate describes the potential mainly using technology already available, together with slight organizational and behavioural changes. In total, this estimate produces a factor 1.5.
- The second estimate gives an example of the combination of more extensive organizational changes to food flows, and considerable changes in individuals' behaviour when it comes to choosing food. In total, this estimate gives a factor 2.

Examples of energy efficiency

Figure 1 demonstrates how significant energy savings can be achieved by using already available technology and implementing organizational and behavioural changes.

Within *agriculture*, the energy consumption needed for production of foodstuffs might be reduced by 30%. Two ways of doing so are use of more efficient production methods (which give a higher yield) and better utilization of fodder.

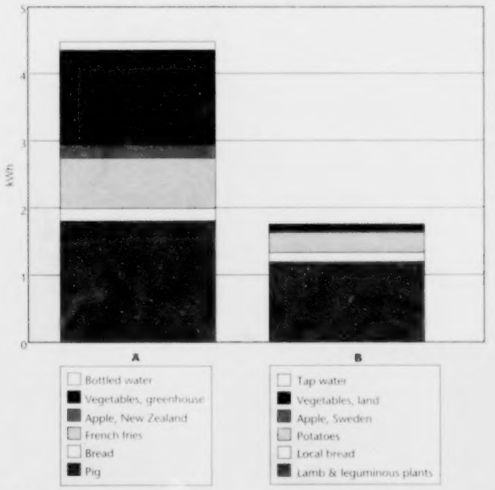
The *food industry* can reduce its energy consumption by 15-30 %. This has been indicated in a project run by the Swedish energy authorities in cooperation with several industrial companies (**good example 1**).

The *trade sector* (wholesalers and retailers) can reduce their energy consumption by one-third. Experiences of a Swedish supermarket chain and food distribution warehouse demonstrate that smart and simple methods like lids on freezers, night curtains for refrigerated display units, and reviews of lighting and ventilation systems can produce considerable savings. A technical breakthrough, which was the result of a competition, made possible the introduction of a refrigerated display counter that is almost 70% more efficient than today's technology.

If *households* buy refrigerators and freezers that are energy-efficient (improved insulation, heat pumps and compressors), food-related energy consumption can be reduced by 50% in one generation. It has been estimated that modernization of Europe's white goods stock is equivalent to a quarter of the total reduction of CO_2 emissions the EU agreed to achieve at Kyoto.

Transportation to and between stores can be reduced considerably if different suppliers cooperate and use delivery vehicles more effectively. For example, if loading is coordinated (so-called "groupage traffic"), haulage distances to the shops

Figure 2
Second estimate: energy savings with a difference of factor 2 between two foods



The difference in energy consumption between different foods chosen by the consumer and, in a wider perspective, the importance of how food flows in society are organized. Some possible changes suggested by this example are more local food (when it saves resources), more vegetables from land, and less meat and more leguminous plants. In addition, consuming lamb promotes biodiversity.

- Exchanging the vegetables grown in a heated greenhouse with those grown outdoors reduces energy consumption for vegetables by more than factor 10.
- Replacing some of the meat reduces energy consumption. There is a difference of roughly factor 4 between pork and leguminous plants.
- Choosing a Swedish apple instead of one from New Zealand yields improved energy efficiency of about factor 6.
- Flavoured tap water instead of imported mineral water represents an energy saving of about factor 20. There is a difference of between factor 500 and 1000 between tap water and imported mineral water.
- Choosing boiled potatoes instead of french fries represents energy efficiency of factor 2, and locally baked bread represents factor 1.2.

Good example 1: dairy achieves energy savings of about 25%

A dairy in southern Sweden has implemented a number of measures in recent years that reduced energy consumption on-site by 25-30%. They have been implemented gradually, after having studied energy consumption carefully. Important measures are: installation of a frequency converter to control electric motors; more modern wiring; better control of refrigerator compressors and heat pumps; and improved lighting. With further measures that are already planned, the company estimates it can save another 10%. For example, it is considering changing the ventilation coolant and installing electrode-less lighting in the freezer room.

(Personal communication, Per-Olof Bergström, Carlshamn Mejeri AB.)

can be reduced. Many different lorries deliver goods to the average supermarket each day. This means a large hypermarket can receive 50 deliveries a day and a smaller shop around ten to 15. There are several examples in Sweden, Denmark and the UK of groupage traffic having been introduced with profitable results (**good example 2**).

To sum up the above results, it might be possible to reduce total energy consumption in the food supply chain by about 30%, which is equivalent to a factor 1.5. Most of the changes can be profitable for businesses.

What the consumer can do: choice of food

Let us compare two meals to find out what the future could look like. **Figure 2** shows the difference in energy consumption between two different choices of food made by the consumer. In a wider perspective, the figure illustrates the importance of how food flows in society are organized. The data are based on life-cycle analyses.

Changes for pesticides and fertilizers

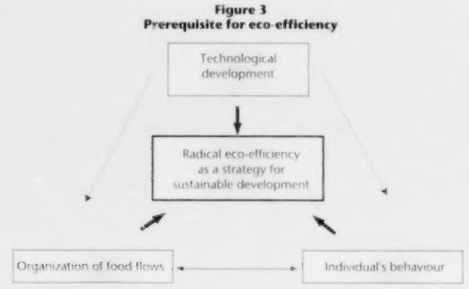
According to the Swedish case study, it should be possible to reduce pesticide use by 60% (i.e. between factor 2 and factor 3) within one generation. One important measure is the increasing share of ecological production. The application of artificial fertilizers can be reduced through precision use and by increasing the proportion of ecological agriculture. Further improvements are achievable by increasing the amount of phosphorus returned to arable land from society. Emissions of nutrients can also be reduced through consumers' choice of food. Important factors are the amount and source of the protein consumed (nitrogen) and the consumption of food additives (phosphorous).

Good example 2: groupage traffic reduced haulage by 75%

In Greater Stockholm, a food chain has coordinated its deliveries from about 50 of its suppliers to all its different shops (eight hypermarkets and 170 smaller shops). This has led to 75% less distance travelled, i.e. a reduction in haulage of factor 4. To manage this, a new terminal has been built for consumables, to which the various suppliers deliver their goods. Here the goods are repacked per shop. This means the shops receive a greater quantity of goods once or perhaps twice a day, rather than a number of smaller deliveries several times a day. In this way, shopkeepers can receive goods from small-scale suppliers every day instead of (perhaps previously) only a couple of times a week. Large-scale suppliers such as dairies, breweries and bakeries still deliver their goods themselves.

(Personal communication, Göran Björkman, KF.)

Figure 3
Prerequisite for eco-efficiency


Technological development
Radical eco-efficiency as a strategy for sustainable development
Organization of food flows
Individual's behaviour

To achieve radical eco-efficiency in the food supply chain, good interplay is necessary between technological development, organization of food flows and the behaviour of individuals.

Technological development: This is a question of developing and spreading technology that produces, transports and stores food using less energy and other resources. With the help of technology, the production of, say, a food commodity or a refrigerator is changed so that less energy is used to produce the same product.

Organization of food flows: This is a matter of logistics. An example is the location where a food commodity is produced. Is it far from the producer to the consumer? There is also the question of how goods are transported from point A to point B. Is it a direct route or via point C? Is the transport vehicle being used to full capacity or only half-filled?

Behaviour of the individual: Changed behaviour means in this context that consumers and food companies include the environmental aspect when they make choices, and thereby to a greater extent begin choosing food and refrigerators that are more eco-efficient.

Consumers heading for the factor 4 strategy

An important measure to be employed in order to reduce utilization of resources in agriculture is to reduce wastage, i.e. reduce the amount of that which is produced but not consumed. This is a problem within the EU. Fruit and vegetable wastage in certain cases is as high as 50% of the harvest. Products are discarded in order to maintain prices at the level of highest-quality products. Using most of the harvests would be equal to a factor 2.

One might question the consumption of non-essential foodstuffs. By *reducing consumption of non-essential food*, consumers could greatly increase the chances of achieving the factor 4 strategy while at the same time improving their health.

Food production in the future – towards sustainability

We are in need of several measures to reach sustainable development and to improve eco-efficiency in the food supply chain. An optimum and cost-effective combination of measures at all levels is required, involving all relevant participants in society, particularly governments, business, industry, agriculture and households. Cooperation in various forms is also necessary, for example negotiations and agreements both nationally and internationally.

If current trends in food consumption continue, the prospect of achieving sustainable food consumption within a reasonable time may be poor. To make sure the development of an eco-efficient and sustainable food supply chain is successful, *we need a good climate for technological development, effective instruments, better organized food flows, committed producers and retailers, and, not least, committed and demanding consumers.* Clear and consistent rules and regulations are also factors that can be propitious for the development of an eco-efficient food supply chain.

The food supply chain is necessary for our continued existence, and we cannot survive long without it. Eco-efficiency of factor 4 in one generation is often discussed today, but will it be possible to integrate into the food supply chain? The answer is that a lot can be done. And there are many "win-win" solutions that are good for both the environment and the profitability (and image) of companies. The issue deserves more thorough study from a global perspective.

Figure 3 illustrates the eco-efficiency prerequisite.

References

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Swedish Environmental Protection Agency (1999) *Sweden in the Year 2021.*

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The International Agri-Food Network and the Commission on Sustainable Development

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The International Agri-Food Network (IAFN) was formed at the time of the 1996 FAO World Food Summit to coordinate activities in relations with international organizations in the field of agricultural development. The IAFN is simply a discussion forum in which participants can identify their common concerns and share experiences with various approaches.

Most of the associations linked by the Network represent a large number of constituents: not just high-profile multinational companies, but also small and medium-sized enterprises in both developing and industrialized countries. Some comprise federations of national and regional associations, which in turn represent sub-national members, while others are structured with a combination of both. Importantly, some also include both private and public sector interests in their membership.

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Regular participants in the IAFN

IAFN participant	Description and major activities
Global Crop Protection Federation (GCPF) *www.gcpf.org*	GCPF represents about 90% of the crop protection industry in over 75 countries and their regional associations in the Asia-Pacific region, Africa, the Middle East, Europe, North America, Latin America and Japan. GCPF promotes the safe, effective and judicious use of crop protection products, implemented within the framework of Integrated Pest Management (IPM), to help ensure adequate yields of high-quality food, feed, fibre and other useful products.
International Association of Plant Breeders for the Protection of Plant Varieties (ASSINSEL) *www.worldseed.org*	ASSINSEL is composed of 44 individual organizations involved in plant breeding in over 31 developed and developing countries, which in turn represent more than 1000 companies worldwide. ASSINSEL seeks to increase recognition of plant breeders' contribution to world agriculture and horticulture.
International Chamber of Commerce (ICC) *www.iccwbo.org*	The ICC's purpose is to promote international trade, investment and the market economy system. It was founded in 1919 and now groups thousands of member companies and associations from over 130 countries.
International Co-operative Alliance (ICA) *www.coop.org*	The ICA is an international non-governmental organization which unites, represents and serves cooperatives world-wide. Among other activities, ICA provides technical expertise for development of cooperatives in Africa, Asia, Latin America, and Central and Eastern Europe.
International Dairy Federation (IDF) *www.fil-idf.org*	IDF's mission is to promote and enhance the image, trade, production and consumption of milk and milk products world-wide by collecting and disseminating scientific, technical and economic information and providing a platform for meaningful exchange of professional knowledge and discussion.
International Federation of Agricultural Producers (IFAP) *www.ifap.org*	The IFAP is the international organization of the world's farmers, with a membership divided equally between developing and developed countries. IFAP was established to secure the fullest cooperation between organizations of agricultural primary producers in meeting the optimum nutritional and consumptive requirements of the peoples of the world, and in improving the economic and social status of all who live by and on the land.
International Fertilizer Industry Association (IFA) *www.fertilizer.org*	IFA is a non-profit industrial organization with around 500 member companies in about 80 countries. IFA actively promotes the efficient use of plant nutrients to maintain and increase agricultural production in a sustainable manner.
International Meat Secretariat (IMS) *www.meat-ims.org*	The IMS, founded in 1974, is a non-profit organization that promotes and develops all aspects of the international meat and livestock trade. Its membership is open to all organizations involved in the meat industry.
International Seed Trade Federation (FIS) *www.worldseed.org*	FIS is a federation of national associations and individual seed companies spread over 65 countries. FIS develops and facilitates the free movement of seeds with fair and reasonable regulations to serve farmers, growers and consumers while protecting intellectual property. FIS encourages the use of modern technologies in high-quality seeds to contribute to sustainable agriculture.
World Federation of the Animal Health Industry (COMISA) *comisa@fedesa.be*	COMISA is the global federation representing manufacturers of veterinary medicines, vaccines and other animal health products in both developed and developing countries across five continents. Its goal is a harmonized, science-based regulatory and trade framework that supports a global animal health industry which is economically viable and high-technology driven, contributing to a healthy and safe food supply.
Other sectors	The biotechnology, food processing, distribution and retail sectors – which do not have an international-level association – are represented by regional organizations, depending on where a given IAFN meeting or activity is taking place. For practical reasons, this is often the European association.

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The interdependence of the industries providing essential inputs, agricultural producers, cooperative organizations and companies involved in food processing and distribution mean that the issues facing one sector of the food chain affect other sectors, upstream and downstream. With the help of UNEP, the IAFN is seeking to explore the complex issues involved by adopting a life-cycle approach covering all the various links in the agri-food chain.

Challenges facing the International Agri-Food Network include persistent hunger and malnutrition throughout the world, exacerbated by growing populations and changing patterns of food consumption. But responses to these demands are constrained by the decreasing amount of available arable land and ever scarcer supplies of water. In short, the activities of the IAFN organizations are carried out within the framework of striving to achieve sustainable agriculture and food security.

The IAFN is extremely sensitive to environmental issues, because the future success of the food chain sectors represented depends on the continued good environmental health of agricultural lands.

A modern, virtual network

The IAFN is unique because it is not a formal organization or association. The IAFN fosters dialogue and consultation through an informal network to improve communications between participants. Shared expertise and cooperative actions also help the associations increase the efficiency of their resources.

This network also makes it easier for agri-food businesses to dialogue with international organizations and NGOs: the IAFN provides a single point of contact and a group qualified to discuss issues affecting the whole of agri-business. Subjects like sustainable agriculture and sustainable development are most effectively addressed in a cross-sectoral forum.

The IAFN believes its flexible "non-institutional" framework, which moulds to the needs of the group or the topic under discussion, is a useful model for other groups to follow. Participating organizations alternate as meeting host and are encouraged to develop smaller groups on specific projects or topics.

More details, including contact details, can be obtained at the IAFN web site: *www.agrifood.net*.

The IAFN and the Commission on Sustainable Development

The eighth session of the UN Commission on Sustainable Development (CSD-8) in April 2000 will focus on the "Integrated Planning and Management of Land Resources," including sustainable agriculture. The International Agri-Food Network recognizes the importance of its participants' technologies, expertise and implementation to sustainable agriculture, and has accordingly set participation in CSD-8 as a priority.

The IAFN is responding positively to the request to act as the organizing partner representing business and industry for the multi-stakeholder dialogue that will take place during CSD-8. The International Federation of Agricultural Producers (IFAP) has been invited to represent the world's farmers during this key dialogue, and will thus sit on a second side of the four-sided dialogue table. The fruitful relationship between IFAP and the other IAFN participants will help assure a constructive dialogue. One of the basic principles behind the International Agri-Food Network is that without a strong partnership between traditional agri-business and farmers themselves, food security and sustainable agriculture are not possible.

The run-up to CSD-8 has already provided valuable opportunities for fostering multi-stakeholder dialogue. Monthly teleconferences have brought together agri-business, farmers, NGOs and trade unions to prepare the April session. This regular contact has helped identify areas of potential cooperation and will help translate sometimes difficult relations between the various stakeholders into a long-term constructive debate on how best to achieve sustainable agriculture in practical terms.

CSD-8 will also provide an opportunity for agricultural experts from governments, NGOs and agri-business organizations to come together to discuss best practices for achieving their common goal of sustainable agriculture. It will resemble a "policy trade fair" on sustainable agriculture, allowing policy-makers to have an overview of the available tools. Case studies will be particularly useful to show how the proper mixture of techniques and technologies, applied within the framework of a programme like Integrated Crop Management (ICM), contribute to social progress and environmental protection as well as agricultural production. The various sectors that participate in the IAFN will therefore send experts to discuss specific projects, both in the dialogue session and in side events where further information can also be distributed.

Recognizing that its participants possess expertise at all links in the food chain, the IAFN is seeking to contribute to this high-level consultation on sustainable agriculture in as many ways as possible. To this end, the IAFN was a partner in the September 1999 conference on the "Multifunctional Character of Agriculture and Land" organized in Maastricht by the FAO and the Government of the Netherlands.

IAFN cooperation with UNEP

The IAFN and UNEP are cooperating on a number of projects leading up to, and during, CSD-8. This special edition of *Industry and Environment* is evidence of this partnership, together with the Workshop on Sustainable Agri-Food Production in October 1999 when the articles contained herein were presented and discussed.

The IAFN will continue to cooperate with UNEP to identify opportunities for agri-food business sectors to optimize their input to the debate on sustainable agricultural development, both in the CSD process and beyond in other fora.

Conclusion

The International Agri-Food Network is a flexible, non-exclusive coalition of agri-business sector associations that cooperate to maximize their collective contribution to sustainable agriculture through the adoption of a life-cycle approach. Despite its "virtual" existence, the IAFN is working positively with FAO, UNEP, OECD, CSD and other bodies to contribute to the development of sustainable agriculture.

Agri-food production in Mexico: the transition to sustainability

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Abstract

Mexico has developed a policy framework for environmental protection that aims to halt and reverse environmental deterioration, some of which has been caused by poor agricultural practices in the past. The major policy goal has traditionally been maximizing incomes, with less emphasis on environmental concerns, but the federal government is now seeking to apply sustainable development principles to agricultural policy. Major problems to be addressed in the agri-food sector include the effects of land degradation and scarcity of water resources, as well as economic and trade-related considerations.

Résumé

Le Mexique a élaboré une politique générale de protection de l'environnement qui a pour but d'enrayer et d'inverser la détérioration de l'environnement, due notamment aux mauvaises pratiques agricoles du passé. Si l'objectif de la politique avait été jusqu'à présent de maximiser les bénéfices, les questions environnementales étant reléguées au second plan, le gouvernement fédéral s'efforce aujourd'hui de fonder sa politique agricole sur les principes du développement durable. Les problèmes majeurs à résoudre dans le secteur agro-alimentaire sont notamment les effets de la dégradation des terres et la rareté des ressources en eau, ainsi que des considérations liées à l'économie et au commerce.

Resumen

México ha desarrollado las bases de una política para la protección medioambiental destinada a frenar y revertir el deterioro del entorno natural, causado en parte por la mala explotación agrícola del pasado. Tradicionalmente, el objetivo estratégico principal era la maximización de los dividendos, prestando poca atención a los asuntos ambientales, pero el Gobierno federal se esfuerza ahora en aplicar a la política agrícola principios de desarrollo sostenible. Entre los principales problemas a solventar en el sector agroalimentario están las repercusiones de la degradación del suelo y la escasez de recursos acuíferos, además de las consideraciones económicas y comerciales derivadas.

Mexico has a long history relating to environmental protection policies. However, only in the last 20 years has a state policy for managing the environment and natural resources been developed, generating radical changes in the legal and institutional framework aimed at stopping and reversing severe environmental deterioration.

The new priorities have been incorporated in the Mexican Constitution, which since 1998 recognizes the right to a healthy environment and the need for sustainable development. This implies a big economic, social and environmental challenge, given the low dynamism of production (mainly in agriculture), compared with population growth, and the extent of poverty (**Table 1**).

A general sustainable production approach has not yet been adopted by all economic sectors. Particularly in agriculture and primary food production, the vision is more fragmented. Although many government (and non-government) programmes are designed to protect natural resources and recover them for agricultural activity, production increases in various production systems have been obtained at the expense of long-term sustainability. There are also rural development programmes for poverty alleviation, which combine production objectives with better soil and water use and pest control.

Dynamics of primary food production

Mexico's food production depends on a wide, heterogeneous range of farms and livestock units. Resources like land, water, inputs, technology, infrastructure, labour and credit vary enormously in quantity and quality. Of 3.8 million production units, over half are smaller than five hectares. One-fifth (18% of cultivated land) have access to irrigation. Those units with the least resources, marginal land quality, low yields and insufficient food production are no doubt worked by poor families. Medium-sized farmers (some with access to irrigation) and large enterprises deal with commercial production.

Agricultural performance has been poor during the last two decades. The influence of deregulation and trade liberalization has varied according to producers' economic capacity and their products' destination market (**Table 2**). Poultry is one of the sectors with the greatest vertical integration, along with considerable concentration. It is domestic market-oriented, while vegetables and fruits are mainly exported. The main vegetable firms are located in northwestern Mexico; their production is based on highly intensive input. Grains include maize (corn), beans, rice, wheat and sorghum. Maize, the national staple crop, is grown on 40% of cultivated land using a wide range of technologies. Most farmers grow it, either for self-consumption or to market.

Traditional itinerant clear-slash-burn (*roza-tumba-quema*) farming and the associated crops are more frequent in the south, with yields of less than one tonne of maize per hectare. New conditions (e.g. population density) have reduced the productivity of this once well-proven and well-adapted system. Most modern techniques applied by medium and large farms, utilizing selected hybrid seeds, mineral fertilizers, chemicals, machinery and irrigation, yield over 15-18 tonnes/ha while the national average is 2.3 tonnes/ha. Increased production by small-scale farmers relies more on the clearance of new land. For many years, mainly in the 1960s and 1970s, large areas of pasture land expanded at the expense of forests. Adverse market conditions have reduced the number of cattle and temporarily increased meat production.

Trade liberalization has stimulated growth in foreign trade of agricultural products in the 1990s. Despite slow growth of imports (6.5% annual average) as compared to exports (11.5%), the external trade balance remains negative. Mexico specializes in vegetable and fruit exports, while depending more on imported grains, oil seed and milk.

Food production and natural resources

Of the 25 million hectares under cultivation, 6 million is irrigated – one of the largest areas of irrigated land in the world. Forest land occupies 21 million hectares (**Figure 1**). Mexico belongs to the 35% of countries with low water availability (4900 m^3 per inhabitant). Average precipitation is abundant, but distribution geographically and throughout the year is very uneven. Hydraulic infrastructure allows irrigation in the north and controls flooding in the south.

Land use affects ecosystems and biodiversity. A high rate of deforestation, inadequate farm practices, over-grazing, over-extraction of water, and insufficient maintenance of hydraulic infrastructure have created pressures on resources and allowed soil and water quality and biodiversity to deteriorate.

A general overview shows severe desertification problems due to soil erosion by water and wind (Figure 2), salinization, and biological, chemical and physical degradation processes that reduce soil fertility and productive potential. Desertification also affects sediment deposit areas. It is estimated that 50% of the territory suffers from erosion and 10% of irrigated land from salinization. Every year 530 million tonnes of fertile soil is lost, affecting 25 million hectares and damaging marginal regions of dry, sub-humid and tropical zones where peasant and indigenous populations live. Irrigated regions with high economic development in the north, northwest and centre are also affected.

Water quality has deteriorated due to contaminants from industrial, agricultural and urban use being carried to the main streams. Agriculture contributes 69% of this residual water, with 76% of fresh water being used for irrigation. Twenty-nine of the 37 hydrological regions are estimated to be polluted. Identified contaminants – not quantified – are active ingredients of pesticides and mineral fertilizers, and soil sediments washed by wind and rain from cropland and overgrazed pasture. There is also an estimated 35% loss of extracted water due to inadequate use, evaporation, or flaws in the conveying systems.

Figure 1
Mexico, land use 1994

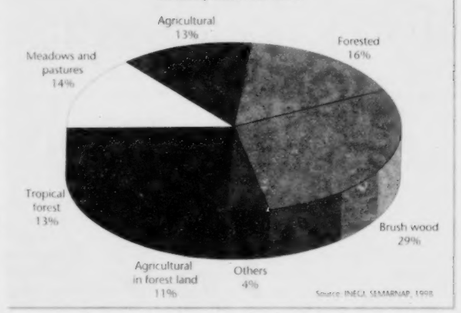


Table 1
Mexico: selected economic and social indicators (%)

	1980-90 Average annual change	1990-98 Average annual change
Population growth	2.1	1.8
GDP growth	1.9	3.0
Agriculture* GDP growth	1.3	1.2
	1990	**1998**
Share of agriculture in GDP	6.1	5.3
Employment in agriculture	22.6	...
Poverty, % households	1994	1996
National	36	43
Rural households	47	53

*Agriculture, forestry, hunting and fishing

Source: ECLAC, 1999

Policies for sustainable food production

Although there is a general, comprehensive environmental policy, the agricultural and rural development policy only partially incorporates environmental protection in its programmes and instruments. Its main goal is increasing producers' net income, mainly through higher productivity in primary food production. The instruments chosen, corresponding to the rural heterogeneity, include general economic support to farmers' income as well as specific assistance to the more deprived peasants to improve their production capacity (SAGAR, 1999).

From an environmental perspective, it should be noted that almost all rural development programmes (from sustainable development addressed to poor families in marginal rural regions, to medium-scale farm capitalization programmes) include at least one component of soil conservation, soil fertility recuperation, water saving, or better fertilizer and pesticide use. The scope – limited by budgetary restrictions – and means of implementation differ.

Another set of programmes designed to protect natural resources relates to reforestation (200,000 hectares a year) and irrigation management.

Government intervention has been oriented to:

♦ *defining the regulatory framework*. This includes general ecological classification of the national territory, as well as issuing and revising rules to prevent and control environmental damage.

♦ *reforestation and soil recuperation*. These programmes promote adequate use of forest land. Actions are taken to return land with low agricultural yield to forest. To guarantee the effectiveness of ecological restoration zones, peasants receive compensation for conservation work replacing their crops. Last year the programme covered 188,000 hectares.

Table 2
Volume index of primary food production
1980-82 = 100

Subsector	1995-97
Dynamic	
Poultry	313
Vegetables	164
Fruits	148
Moderate growth	
Grains	129
Sugar cane/coffee	126
Milk	111
Contraction	
Cattle (inventory)	80
Hogs	71
Oil seeds	52
Population	**134**

Source: Salcedo, 1999

♦ *soil conservation linked to productive projects*. This is a basic component of various programmes (some carried out by NGOs) designed to alleviate poverty in marginal rural areas. In some regions, changes in the traditional itinerant maize-growing system have been successfully introduced. Using new farming practices that allow land to lie fallow, as well as green fertilizers and integrated pest control, the transformed system recovers soil fertility, liberalizing land at the same time, preventing loss of humidity, doubling yields and allowing a second crop every year. Thus a peasant may multiply food production by four, improve food security, and earn money from other activities.

During the last two years, this programme has been reinforced to prevent fires on over 100,000 hectares out of the 500,000 where the traditional system is usually applied. In 1998, forest fires affected about 850,000 hectares. Over half the fires originated during agricultural activities (pasture burning and itinerant production practices). The actions taken reduced the area affected by over 70% in 1999.

Women have received increasing attention in production projects, improving household food security. In particular, the development of backyard production systems should be mentioned; 400 systems have been identified to date.

♦ *farms' capitalization and minimum cultivation*. Addressed to commercial small and medium-sized farmers, these programmes are designed to improve productivity by introducing better farm practices, land use, and water and fertilizer applications as well as pest control. They include government support (30% of the cost) to purchase equipment for minimum cultivation and precision sowing.

Assistance given for purchases of fertilization and irrigation equipment allows more efficient use of water and inputs. It is estimated that savings from the programme are equal to water extraction in the central region of the Bajio. Considerable fuel savings have also been achieved.

♦ *better water management*. Hydraulic infrastructure is being transferred to users, who should be responsible for maintenance and rational water use. Control of agricultural contaminants at source is still lacking.

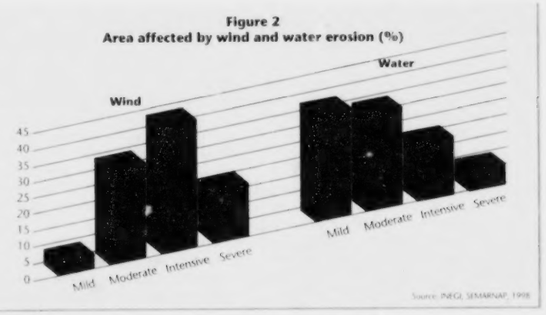
♦ *application of fertilizers and pesticides*. An intersecretarial commission controls the processing and use of mineral fertilizers, pesticides and toxic substances. The industry is promoting a "clean landscape" pilot programme concerned with final disposal of input containers, as well as joint public-industry training programmes on adequate raw materials selection, dosage and use. Voluntary local agreements are being promoted to reduce river basin pollution.

♦ *biosecurity*. A inter-secretarial and biosecurity commission has been created to establish policies regarding GMO production, marketing and use. There is also a biosecurity consultantancy commission dealing with GMOs' effects on health and the environment. Although their technological benefits cannot be denied, a cautious position has been adopted because of the impact inadequate management could have on a number of foods of national origin including peanuts, chilies, maize, beans and tomatoes.

These positive steps could have a wider impact on sustainable food production if it were possible to afford more resources to implement better agricultural practices. However, it seems that an analysis product-by-product and according to production systems – e.g. following a life-cycle assessment – should allow better identification of agriculture's critical socio-economic and negative environmental effects and their causes. Implementation is a complex process which must consider the information and education needed to change attitudes, as well as family farms' special difficulties in adapting to changing environmental requirements, not to mention financing pollution control practices (Tobey and Smets, 1996).

The views expressed in this paper are the author's own and do not necessarily reflect those of any institution.

Figure 2
Area affected by wind and water erosion (%)



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Tobey, James A. and Henri Smets (1996) The Polluter-Pays Principle in the Context of Agriculture and the Environment. *The World Economy*, Vol. 19, N° 1, January, Blackwell Publishers. ♦

Selected sustainable agriculture and food production events in the year 2000

10-13 January 2000: OECD Conference of Heads of Agricultural Research, Extension and Higher Education (Agricultural Knowledge System), in Paris, France. For more information, contact: OECD Secretariat, Fax: + 33 (1) 44 30 61 16, E-mail: Ferdinand.Kuba@oecd.org, Internet: www.oecd.org/agr/aks/index.htm.

14-18 February 2000: International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century, in New Delhi, India. For more information, contact: A.K. Singh, Secretary-General, Indian Agricultural Research Institute, New Delhi, 110 012 India; Tel: +91 (11) 573-1494; Fax: +91 (11) 575-5529; E-mail: icmnr@bic-iari.ren.nic.in.

20-25 February 2000: Conference on Aquaculture in the Third Millennium, in Bangkok, Thailand. For more information, contact: Network of Aquaculture Centres in Asia-Pacific, P.O. Box 1040, Kasetsart Post Office, Bangkok 10903, Thailand. Tel: +66 (2) 561-1728 to 9, Fax: +66 (2) 561-1727, E-mail: naca@fisheries.go.th.

28 February-1 March 2000 Assessing the Safety of GM Food – the OECD Edinburgh Conference on the Scientific and Health Aspects of Genetically Modified Foods, in Edinburgh, Scotland, UK. For more information, contact: Helen Fisher, OECD, Tel: +33 (1) 45 24 80 97, E-mail: Helen.Fisher@oecd.org.

16-22 March 2000: The World Water Council's Second Water Forum and Ministerial Conference, including sessions on agricultural water resources, in The Hague, the Netherlands. For more information, contact: Ministry of Foreign Affairs, PO Box 20061, 2500 EB The Hague, the Netherlands; Tel: +31 (70) 348-5402, Fax: +31 (70) 348-6792, E-mail: Hans.Van.Zijst@dml.minbuza.nl.

27-31 March 2000: Biosafety 1. Science and Policy in Risk Assessment of Transgenic Organisms: A Case Study Approach, workshop sponsored by the International Centre for Genetic Engineering and Biotechnology (ICGEB), in Trieste, Italy. For more information, contact: Micaela Di Blas, ICGEB, Padriciano 99, 34012 Trieste, Italy. Tel: +39 (40) 375 7333, Fax: +39 (40) 226 555, E-mail: courses@icgeb.trieste.it, Internet: www.icgeb.trieste.it/biosafety.

28 March-1 April 2000: Third International Congress of the European Society for Soil Conservation in Valencia, Spain. For more information, contact: sabina.asins@uv.es, Centro de Investigaciones sobre Desertificacion – CIDE Apartado Oficial, Tel: +34 (96) 126-0126, Fax: 34 (96) 127-0967, Internet: www.uv.es/cide.

3-8 April 2000: ICGEB workshop, **Biosafety 2. Advanced Research and Procedures: Case Studies for Designated Experts** in Florence, Italy. For more information, contact: Micaela Di Blas, ICGEB (see above).

24 April-5 May 2000: Eighth Session of the Commission on Sustainable Development (CSD-8), including sessions on integrated planning and management of land resources, agriculture, and financial resources/trade and investment/economic growth, in New York. The CSD Ad Hoc Intersessional Working Groups meet in New York from 22 February-3 March 2000. For more information, contact: Andrey Vasilyev, UN Division for Sustainable Development, Tel: +1 (212) 963-5949, Fax: +1 (212) 963-4260, E-mail: vasilyev@un.org, Internet: www.un.org/esa/sustdev/. For major groups information, contact: Zehra Aydin-Sipos, Major Groups Focal Point, Division for Sustainable Development, Tel: +1 (212) 963-8811, Fax: +1 (212) 963-1267, E-mail: aydin@un.org.

May 2000: Fifth Consultation on the Prevention and Disposal of Obsolete and Unwanted Stocks of Pesticides, in Rome, Italy. For more information, contact: Ale Wodageneh, FAO, Tel: +39 (6) 5705 5192, Fax: +39 (6) 5705 6347, E-mail: A.Wodageneh@fao.org.

18-21 May 2000: Pesticide Action Network Conference on Healthy Agriculture for Healthy Food, in Dakar, Senegal. For more information, contact: Pesticide Action Network Africa, Tel: +221 (825) 4914, Fax: +221 (825) 1343, E-mail: panafrica@telecomplus.sn.

4-7 July 2000: OECD Workshop on the Adoption of Technologies for Sustainable Farming Systems, in Wageningen, the Netherlands. For more information, contact: Ronald.Steenblik@oecd.org

18-21 September 2000: 26th Session of the FAO Committee on World Food Security, in Rome, Italy. For more information, contact: Barbara Huddleston, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy. E-mail: Barbara.Huddleston@fao.org.

11-29 September 2000: 25th Session of the Joint Meeting, FAO Panel of Experts on Pesticides Residues in Food and the Environment and the WHO Expert Group on Pesticides Residues, in Geneva, Switzerland. For more information, contact: Amelia Tejada, FAO, Tel: +39 (6) 5705 4010, Fax: +39 (6) 5705 6347, E-mail: Amelia.Tejada@fao.org.

Sustainable agricultural development in China

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Abstract
Feeding its huge population has always been the most important consideration of Chinese agricultural policy. Environmental problems are now focusing more attention on sustainable agriculture as a way to preserve the resources needed to produce enough food. China's policies aim to maintain the primacy of agriculture, strengthen farmland conservation measures, and provide assistance to farmers in using environmentally sound practices.

Résumé
Nourrir une population extrêmement nombreuse a toujours été la préoccupation première de la politique agricole chinoise. Mais les problèmes environnementaux ont attiré l'attention des responsables sur une agriculture écologiquement viable comme moyen de préserver les ressources indispensables pour produire de quoi nourrir l'ensemble de la population. La politique chinoise a pour but de maintenir la primauté de l'agriculture, de renforcer les mesures de conservation des terres agricoles et d'aider les agriculteurs à adopter des pratiques écologiquement rationnelles.

Resumen
El factor al que la política agrícola china ha conferido siempre mayor relevancia es la alimentación de su inmensa población. Los problemas ambientales han centrado ahora la atención en la agricultura sostenible como método de preservación de los recursos necesarios para producir comida suficiente. La política china aspira a mantener la primacía de la agricultura, fortalecer las medidas de conservación de las tierras de labranza y proporcionar asistencia a los agricultores para que puedan emplear métodos positivos para el medio ambiente.

China has insisted on a principal policy of paying great attention to agriculture and food production since the early 1950s. Food for its huge population has always been the most important issue, especially in view of the country's very limited amount of arable land. The government has not slackened its attention to this issue, while farmers have been encouraged to develop a diversified rural economy and to increase their income since the socialism-market economy came into effect in 1994.

China has a population of 1.3 billion, with per capita arable land of 0.08 hectare (ha). Under these conditions, annual grain production of nearly 500 million tonnes has been maintained in recent years, with per capita grain production of about 400 kg. Self-sufficiency in food supply has basically been realized: per capita meat, eggs, aquatic products and vegetables are above the world averages of 41.3, 19.5, 13.0 and 198 kg, respectively. Nevertheless, China is faced with environmental and resource challenges in regard to further development of agriculture and food production. Its population continues to grow, while arable land is decreasing. Some of the problems are described below:

◆ *Serious limitations on the principal resources required for agricultural development.* There is only about 300 million ha of reclaimable land, while about 200 thousand ha is lost every year, largely due to construction. Per capita water run-off is 2400 m^3/yr, only a quarter of the world average.

◆ *Chemical pollution by wastes from industries, cities and the heavy application of agro-chemicals.* About 20% of groundwater is unsuitable for irrigation due to significant pollution. Chemical pollution directly affects about 10-20 million ha of farmland, out of some 120 million ha of total arable land. Simultaneously, agro-produce is also clearly polluted (up to 2-3% of the entire output).

◆ *Resource deterioration and ecosystem imbalance.* The content of organic matter in the soil of arable land has a tendency to decrease after a long period of intensive cultivation, and 79% of farmland has fertility problems of various kinds. Soil and wind erosion has damaged areas of up to 3.60 and 2.62 million km^2, respectively, and the destruction of vegetation has affected half of the national territory. Annual loss of mud and sand is as much as 5 billion tonnes, resulting in serious silting up of waterways and a growing threat of flooding. Disasters due to pests and climate change are also increasing. The total area damaged per year has been: 100-200 million ha in the 1950s, 200-300 million ha in the 1970s, and 300-500 million ha in the 1990s.

Under such conditions, the difficulty of realizing sustainable development of agriculture and food production in China is obvious. To guarantee agriculture and food production so as to meet the requirements of the growing population and economic development, policy countermeasures are taken as follows:

1. *The fundamental position of agriculture in the national economy is always placed on the agenda and rapidly emphasized.* The doctrine that "agriculture is the basis of the national economy" is known by everybody and has been regarded as a basic principle for planning of social development in various periods. The government has continued to hold an annual national conference to discuss agriculture and rural development. The first government document circulated each year is usually concerned with this subject. In recent years, there have been successive bumper harvests. There is enough grain and to spare in many places. Under these conditions, however, the government has not reduced the requirement for agricultural development.

2. *There has been a strengthening of laws, regulations and policies in regard to farmland conservation, especially striving to maintain the existing gross acreage of the national farmland.* In 1997, China revised the Land Management Law and promulgated the Regulations regarding the Freezing of Farmland Occupation by Non-Agricultural Construction Projects. The situations of farmland occupation were examined, and a strict procedure for examination and approval of such occupation was regulated. In recent years, occupied farmland has amounted to about 200,000 ha annually, a decrease since before 1995, when 300 thousand ha of farmland was lost annually. In 1998, the Regulations regarding Conservation of Elementary Farmland were revised. More than 90% of the farmland now available is to be gradually categorized as "elementary farmland in conservation" and no longer allowed to be occupied. The management, monitoring and supervision of the ecosystem and of environmental quality in rural areas have also been strengthened.

3. *A series of policies and countermeasures have been implemented to encourage farmers' activities.* For example, land ownership by contracted farmers has existed since 1978, when the rural reforms began. Both the systems in effect have insisted on enforcement: the system of contracted responsibility linked to output, primarily based on farmer household management; and the system of double management in combination with the collective entity, where the household is run separately. The land contracted by farmers is allowed to be used continuously for another 30 years after the end of the first contract period. In addition, a series of other policies have been implemented to encourage farmers' activities, including encouraging their well-being through diversified economic development of the contracted land; promoting poverty relief through economic development; and guaranteeing a stable grain purchase price for the contracted farmers.

4. *There has been a strengthening of the conservation of agricultural ecosystems and the environment, and vigorous development of eco-agriculture.* Since the beginning of the 1990s, countermeasures for conservation of the environment and natural resources have been increasingly reinforced. A series of plans were drawn up to promote simultaneous development of the national economy and environmental protection. These plans include China's Agenda 21, the Action Plan for Agriculture, and the Action Plan for Biodiversity Conservation. In the Outline of the Ninth Five Year Plan and the Perspective Objectives for 2010, sustainable development is considered the basic national development strategy, and environmental protection is a basic national policy. In this planning outline, a principle for agriculture has been regulated as "vigorous development of eco-agriculture and protection of the agricultural ecosystem and the environment". After a flood disaster in 1998, the central government held a conference and an important decision was made concerning agriculture and rural development. Countermeasures for improving the agricultural environment have been strengthened and clearly listed, in an unprecedented way, in a central government document.

To achieve simultaneous development of agriculture and environmental protection, China has implemented the following policies and countermeasures up to now:

◆ *Ecosystem rehabilitation and construction in agricultural regions is included as a new part of national planning.* Ecosystem rehabilitation for renovation of the whole territory has been proposed, including the well-known protective barrier forests. Countermeasures include construction of farmland systems with water conservation as the fundamental projects; realignment of small valleys; renovation of low-production farmland; building up of windbreaks and vegetation systems; and terracing of slopes and controlling soil erosion.

◆ *Eco-agriculture is being vigorously developed.* Chinese eco-agriculture (CEA) is a successful model of sustainable agriculture suited to Chinese conditions. Its basic objective is to achieve simultaneous development of the agricultural economy with ecosystem conservation. The sustainability of agricultural development in experimental areas has clearly been improved through the work of farmers in building up the ecosystems of agricultural regions, along with developing the rural economy with proper technological support. The practice of CEA includes the following fundamental principles:

a) The development objective for CEA farms or regions must be simultaneously associated with social, economic and ecological benefits.

b) Ecosystem engineering is the backbone technology system of CEA farms or regions. It not only pays attention to the choice of technologies and farming practices, but also attaches importance to their optimal combination. A CEA farm or region is an incorporated ecological-economic system whose sustainable operation should act as a real ecosystem, with the characteristics of "integrity, coordination, recyclable and regenerable". The technologies or models chosen must be optimized in terms of integration of the above benefits.

c) The technology choice and model design must suit local conditions in terms of geography, climate, resources, farming tradition, and the basis of economic development.

The elementary procedures for building up CEA are as follows:

a) A survey is conducted of local ecological-economic conditions. A comprehensive local development plan is then drawn up, based on the survey and a diagnosis of the ecological-resources-economic situation.

b) The technologies available or to be introduced are chosen, and the ecosystem engineering models are designed according to their suitability to local conditions, including the strong or weak aspects of the local ecological-resources-economic situation.

c) Ecosystem engineering is gradually built up, starting with the key projects for rehabilitation or rebuilding of fragile links in the local agricultural ecosystems.

d) The technologies and models chosen are put into operation. Their readjustment is continuously carried out, based on an examination of the benefits and an analysis of the effects.

The central government has supported 51 counties in creating eco-agriculture counties since 1993. The provincial governments together have also supported about 200 other counties in carrying out similar initiatives. Farmers have voluntarily experimented with about 2000 eco-villages or farms. All these experimental sites have obtained quite good results in developing agriculture in synchronization with environment protection.

◆ *Management, monitoring and legislation for agricultural environmental protection have been strengthened.* Agro-environment management and monitoring networks have been established linking the Ministry of Agriculture (MOA) to provinces and parts of counties. The responsibilities and procedures for agro-environment protection are clearly regulated in the revised Agriculture (Basic) Law, and the Provisions regarding Conservation of Elementary Farmland. Supervision and monitoring of the agro-environment, and its protection, are well conducted by these working network systems.

◆ *The guiding principle of agricultural development through "high output, good quality and high benefits" is being actively implemented, and the Quality Revitalization Plan for Agriculture is being carried out.* The quality of agro-produce and the agro-environment have been on the MOA agenda in recent years. The market has imposed the requirement of quality agro-produce once basic consumption needs are met. Under these conditions, a national market guideline of "good price for good quality" has been encouraged. Simultaneously, agro-environment quality management is being reinforced. This includes agro-ecosystem construction; halting farming to restore forest or grass on land with an over 25 degree slope, and on illegally reclaimed grassland and wetland; and measures to protect farmland from chemical pollution. ◆

The OECD approach to sustainable agriculture

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The OECD provides a forum for its 29 Member countries to discuss economic and social policies, based on economic analysis and sharing of country experiences, with a view to offering policy advice and recommendations to governments. In recent years more attention has been paid to mutual interactions between OECD and non-OECD countries, especially in the context of globalization and liberalization of markets, trade and investment.

A major OECD project is currently under way on *Sustainable Development*, drawing on the wide range of socio-economic expertise in the OECD, for presentation to OECD Ministers in 2001 and as an input into the "Rio+10" UN meeting in 2002. On the basis of looking at what's happened, the aim is to outline the way forward for policy-makers in striving to maintain and enhance sustainable development – covering the economic, environmental and social dimensions. The interim report to OECD Ministers in 1999 can be accessed at *www.oecd.org/subject/sustdev*.

The achievement of sustainable systems of agricultural production is widely recognized by governments as a long-term policy objective – to ensure that the demands of people for sufficient, safe and secure supplies of food and fibre are satisfied in cost-effective and least trade-distorting ways (economic sustainability) while maintaining the resource base and improved environmental performance (environmental sustainability). Most recently, there has been a growing interest in the role of agriculture in contributing to societal values (social sustainability).

The OECD project includes a chapter on *Sustainable Agriculture*. This article briefly outlines the approach and perspective of the work under way in the OECD. *The overall objective is to provide sound analysis to help in the design and implementation of policies able to promote sustainable agriculture and the management of natural resources in the context of agricultural and trade policy reform.*

The challenge for policy-makers is to devise approaches and instruments that facilitate the process of sustainable agriculture. This has a number of aspects: how and when to complement the information and signals conveyed by markets; how to develop and improve legal structures and institutions that can clearly define and enforce property rights with regard to environmental damage and benefits from agricultural activities; how to take account of social concerns (which is less developed than understanding the economic and environmental linkages); and how to reform agricultural and agri-environmental policies so that they are targeted to environmental outcomes in least trade distorting ways.

What have been the results so far of the work in the OECD?

♦ Sustainable agriculture is a process by which agricultural activities contribute to non-declining welfare and overall sustainability in the overall economy. This means that maintaining the activity of any sector, such as agriculture, should not be at the expense of compromising the achievement of sustainability in the economy as a whole.

♦ The demands on resources in the agricultural sector are increasing (from a growing and richer population for food and fibre), changing (to meet higher standards of environmental quality), and under growing pressure from competition for other uses (especially of productive land and supplies of water). While the supply of food and fibre is increasing with higher yields from using less land, a result of the adoption of technologies and improved farming practice, the effect on sustainability depends on weighing up the costs and benefits of environmental damage and the provision of environmental benefits, while taking account of social concerns.

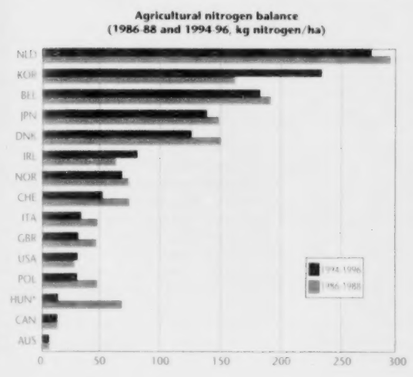
♦ In general, over the last 15 years the output of food and fibre in OECD countries has risen by 20%, on 2% less land and with 8% fewer workers. Despite short-term fluctuations, the price of food has declined over the long term. The available evidence in the OECD suggests that there has on average been a 5% decline in nutrient surpluses from agriculture, while pesticide use has fallen in all but three OECD countries over the last decade (see figures). But the overall effect on environmental quality is not clear, and the pattern of effects varies considerably across and within OECD countries. The "site specificity" of agro-ecological conditions is crucial with regard to many of the environmental effects, depending on the appropriate management of farming practices and the set of incentives/disincentives.

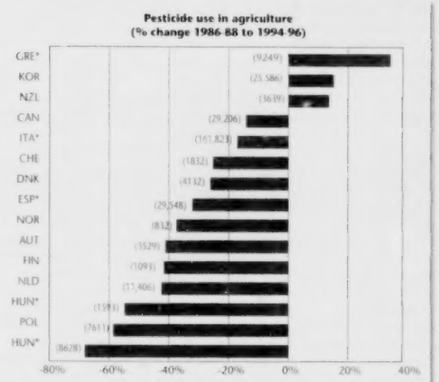
♦ Agriculture in OECD countries displays many of the characteristics of other economic sectors with regard to sustainability – meeting increased demands with scarce resources, applying better technology, and satisfying demands through combining or substituting resources. But there are also some characteristics of particular significance in the case of agriculture (and forestry) as a major land and water using activity, affecting natural resources, biodiversity, habitats and rural landscapes.

♦ Agriculture is also a heavily supported activity. In 1998, total support to agriculture in OECD countries was US$ 360 billion, or around 2.1% of total OECD GDP. Support to farmers (measured by the OECD's "Producer Support Estimate") was equivalent to about 37% of the value of their gross farm receipts. Two-thirds of the support was channelled through policy measures that kept domestic producer prices 40% above world prices. While support has fallen over the last decade, and less support is directly linked to commodity production, there are still large variations across countries and commodities. As the environmental outcomes associated with agricultural activities are closely related to the level of production and its location, they are directly associated with farm practices linked to the levels and types of support. But while specific agri-environmental measures increasingly provide payments to farmers for reducing environmental damage, and for providing environmental services, these sometimes only offset the effects of high levels of agricultural support. Economy-wide environmental regulations and standards are also increasingly impinging on farm activities and costs of production.

♦ The reform of agricultural policies and trade liberalization over the last decade, due to domestic and international pressures, have contributed to some improvement in environmental quality through higher growth and improved resource allocation. But reforms have also led to environmental concerns: where agricultural activities that provide environmental benefits have become non-viable; where the non-accountability of environmental costs and benefits in agricultural commodity prices results in inefficient resource allocation; and where there are global environmental effects from domestic actions, leading to "free-rider" problems. Policies aimed specifically at improving environmental performance are increasingly being implemented in OECD countries, but they account for a small share of support to agriculture. One of the policy challenges is to switch from policy measures that support production of commodities in ways that harm the environment (perverse subsidies) to those that are decoupled from production, targeted to environmental outcomes in non-trade distorting ways.

♦ The work in the OECD is confirming other studies showing that: the agri-food sector needs to be economically viable in order to provide the means for producers to be environmentally sustainable; agricultural policy reform and trade liberalization are necessary, but not always sufficient to ensure agricultural sustainability; policies need to be better targeted to improve environmental quality in agriculture so as to avoid compromizing trade liberalization; while trade policies need to avoid compromizing agricultural sustainability, and those environmental effects that are domestic in scope should be addressed through appropriate domestic policies. But a lot more work needs to be done to define the characteristics of "good, coherent" agricultural, environmental and trade policies.





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Feeding nine billion*

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Abstract

Technological advances have revolutionized crop productivity during this century, but the increase in crop yields has begun to slow while the world's population continues to expand. Land degradation and pressure on water resources present serious obstacles to much-needed increases in land productivity. Meeting 21st-century global food needs will require consistent population control policies, a move to sustainable consumption, and greatly improved efficiency in our use of land, water, and other natural resources. This article provides a forward-looking analysis of these issues and recommendations to address them.

Résumé

Si au cours de ce siècle les progrès technologiques ont révolutionné la productivité agricole, l'augmentation du rendement des cultures a amorcé un ralentissement alors même que la population mondiale continue, elle, à augmenter. La dégradation des sols et la pression sur les ressources en eau font sérieusement obstacle à une productivité accrue des terres, pourtant si nécessaire. Pour satisfaire aux besoins alimentaires de la population mondiale au XXIe siècle, il faudra mettre en œuvre des politiques cohérentes de maîtrise de la démographie, adopter des modes de consommation durables et améliorer considérablement le rendement d'utilisation du sol, de l'eau et des autres ressources naturelles. Cet article propose une analyse prospective de ces questions et des recommandations pour les aborder.

Resumen

Los avances tecnológicos han revolucionado la productividad agrícola durante este siglo, pero el crecimiento de las cosechas enlentece mientras la población prosigue su expansión. La degradación del suelo y la explotación de las reservas acuíferas son los principales obstáculos al tan necesario incremento de la productividad agrícola. Para satisfacer las necesidades alimentarias del siglo XXI, será indispensable aplicar firmemente políticas de control demográfico, pasar al consumo sostenible y optimizar el uso del suelo, el agua y los demás recursos naturales. El presente artículo ofrece un análisis prospectivo de estos temas, así como recomendaciones para abordarlos.

This has been a revolutionary century for world agriculture. When this century began, each American farmer produced enough food to feed seven other people in the United States and abroad. Today, a US farmer feeds 96 people. Draft animals have largely been replaced by tractors; traditional varieties of corn (maize), wheat and rice have given way to high-yielding varieties; and world irrigated area has multiplied six-fold since 1900. The use of chemical fertilizers – virtually unheard of in 1900 – now accounts for an estimated 40% of world grain production.

Technological advances have tripled the productivity of world cropland during this century. They have helped expand the world grain harvest from less than 400 million tonnes in 1900 to nearly 1.9 billion tonnes in 1998. Indeed, farmers have expanded grain production five times as much since 1900 as during the preceding 10,000 years since agriculture began. In the future, however, constraints on available land, water and productivity gains will force societies to find alternative means to achieve sustainable food production.

Land: a finite resource

The option of expanding world grain production by cultivating more land has virtually disappeared. The world's grain harvested area increased from 587 million hectares in 1950 to the historical high of 732 million hectares in 1981, a gain of 25%. Since then, however, the grain area has shrunk to 690 million hectares (a 6% drop) as it was converted to non-farm uses, abandoned because of soil erosion or shifted to other crops. During the next half century the grain harvested area is not expected to change much, with gains and losses essentially offsetting each other.

Some further gains in cultivated area are possible. If grain prices rise in Brazil, for instance, parts of the *cerrado* – a semi-arid region in the east-central part of the country – will likely be brought under the plow. In Africa there are opportunities for expanding the cultivated area in the Congo River basin. And in Asia the outer islands of Indonesia offer some opportunities for increasing cultivation, although as in Brazil the additional land is typically marginal in nature. The inherent fertility of nearly all this land is low, requiring special efforts to maintain productivity. On the other hand, heavy cropland losses during the next half century are expected in countries such as India, where the construction of housing alone will claim a substantial area of cropland. Other countries are losing cropland because of degradation. Kazakhstan, for example, abandoned nearly half its grainland between 1980 and 1998 as a result of soil erosion and other forms of land degradation, letting it revert to rangeland. Other countries in Central Asia, North Africa and the Andean countries of Latin America are also losing cropland to degradation.

Between 1950 and 1998, the grain harvested area per person world-wide shrank from 0.23 hectares to 0.12 hectares. For most countries this was not a problem, as unprecedented increases in land productivity more than offset the shrinkage. Given the marked loss of momentum in raising land productivity since 1990, however, there is reason to doubt that future increases can offset the projected shrinkage in cropland per person to 0.07 hectares by 2050.

A look at this situation in individual countries is both illuminating and worrying. India, which has already tripled its wheat yields and doubled its rice yields, will find it difficult to sustain the rises in land productivity needed to offset the continuing shrinkage in per capita grain area. China is in a somewhat better position. Its projected population growth is much lower than that of India. The question for China is not so much whether its land and other agricultural resources will enable it to feed 1.5 billion people, but whether it can feed 1.5 billion affluent people who are consuming large quantities of livestock products. The countries likely to be in the most trouble over the next half century are those in the second tier in size – those projected to surpass the 300 million mark before 2050 (Pakistan, Nigeria and Indonesia), plus Ethiopia, which will cross the 200 million threshold. Pakistan – with 357 million people in 2050, more than live in the United States and Canada combined today – will see its grain harvested area shrink to 0.03 hectares per person, or less than one-tenth of an acre. Nigeria, whose current population of 115 million is projected to expand to 339 million, will see its grainland per person shrink to 0.05 hectares. Bangladesh, Ethiopia, Egypt and Iran are also facing shrinkages of their grain harvested area per person to dangerously small areas.

A substantial area of grainland is also being lost to oilseeds, importantly the soybean. As incomes have risen in lower-income countries, the demand for vegetable oil for cooking has escalated. There has been enormous growth in the global appetite for soybeans. The area planted in this crop jumped from 14 million hectares in 1990 to 69 million hectares in 1997, with much of the growth coming at the expense of grain.

Water: an emerging constraint

As we move into the new millennium, with water scarcity emerging as the dominant constraint on efforts to expand food production, the focus of yield calculations may shift to the amount of water required per tonne of grain produced. 40% of world food production now comes from irrigated land. The growth in irrigation has permitted the expansion of agriculture into arid regions, increased multiple cropping in monsoonal climates by facilitating cropping during the dry season, and allowed a substantial expansion of fertilizer use.

Irrigated agriculture is concentrated in Asia, which has some of the world's great rivers – the Indus, the Ganges, the Yangtze, the Yellow and the Brahmaputra. Originating at high elevations and travelling long distances, they provide an abundance of opportunities for dams and the diversion of water into networks of gravity-fed canals and ditches. Two-thirds of the world's irrigated area is in Asia. Roughly 70% of the grain harvest in China comes from irrigated land, while the equivalent figure in India is 50% and in the United States 15%.

As the 1990s have unfolded, evidence of water scarcity is mounting. Water tables are falling on every continent – in the United States, much of North Africa and the Middle East, most of India, and almost all flatland in China. David Seckler and his colleagues at the International Irrigation Management Institute in Sri Lanka estimate that underground water withdrawals in India are at least double the rate of aquifer recharge. They report that water tables are falling at one to three metres (three to ten feet) per year almost everywhere. Seckler describes India as being on a free ride, expanding its agriculture by depleting underground water reserves. At some point, he says, this "house of cards" will collapse. When it does, India's grain harvest could fall by as much as 25%. In a country where the supply and demand for food are already precariously balanced, and where 18 million people are added each year, this is not a happy prospect.

Many major rivers run dry before they reach the sea. Some have disappeared entirely. In Central Asia the Amu Darya, one of the two rivers feeding the Aral Sea, is drained dry by Uzbek and Turkmen cotton farmers long before it gets to the sea. As a result, the Aral Sea is shrinking and may eventually disappear, known to future generations only from old maps. Little water from the Nile makes it to the Mediterranean, and the Ganges barely makes it to the Bay of Bengal in the dry season. With the collective population of Ethiopia, the Sudan and Egypt – the three dominant countries in the Nile River basin – projected to grow from 157 million today to 388 million over the next half century, competition for the Nile waters is certain to intensify. The same can be said about the Ganges, where there is keen rivalry between India and Bangladesh for water.

Land scarcity has traditionally shaped grain trade patterns. Now water scarcity is beginning to shape them as well. North Africa and the Middle East, a region where every country faces water shortages, became the world's fastest growing grain import market during the 1990s. To import a tonne of wheat is to import a thousand tonnes of water. In effect, for countries facing water shortages, the most efficient way to "import" water is to import grain. In 1997, the water required to produce the grain and other farm products imported into North Africa and the Middle East was roughly equal to the annual flow of the Nile.

World-wide, roughly 70% of all water diverted from rivers or pumped from underground is used for irrigation, while 20% goes to industry and 10% to residential uses. As countries push up against the limits of their water supplies, the contest between these three sectors intensifies. A thousand tonnes of water can be used in agriculture to produce a tonne of wheat worth $200, or it can be used in industry to expand output by $14,000 (70 times as much). Similarly, if the goal is to produce jobs, using scarce water in industry is far more productive than using it for irrigation. Because the economics of water use do not favour agriculture, this sector almost always loses.

Perhaps more than anything else, growing water shortages may constrain future efforts to expand food production. Water used for irrigation raises land productivity, both directly and indirectly, by increasing the potential for using fertilizer. And in arid regions it determines the amount of land that can be cultivated. The bottom line is that if we are facing a future of water scarcity, we are also facing a future of food scarcity.

Increasing land productivity

In 1950, the average world grain yield per hectare was just over one tonne. By 1998, it had climbed to 2.73 tonnes per hectare. Grain yields vary widely among countries. But in a world where farmers everywhere are drawing on the same backlog of agricultural technology, the variations that were once due to uneven levels of economic development are today explained largely by differences in natural conditions such as temperature, rainfall, day length, solar intensity and inherent soil fertility.

Take wheat, for example. Three developing countries – Egypt, Mexico and China – are in the top five in wheat yield per hectare. And two industrial countries – Canada and Australia – are in the bottom five. This is because Egypt, Mexico and China irrigate most of their wheat, while in Canada and Australia the wheat is rain-fed and grown in areas of low rainfall. The two countries at the top of the list – the United Kingdom and France – are blessed with fertile soils, good rainfall and, because of their northerly latitude, long days during the summer growing season. By contrast, Kazakhstan – at the bottom of the list – relies on some of the most marginal cropland in the world.

The three keys to increases in land productivity since mid-century are plant breeding, the spread of irrigation, and growth in the use of fertilizers. The principal contribution of plant breeders has been to increase the share of photosynthate, the product of photosynthesis, that goes into seed production. There is not much remaining potential for increase, however, since scientists estimate that the absolute upper limit is 62%. Anything beyond that would begin to deprive the rest of the plant of the energy needed to function, thus reducing yields.

A lack of understanding of the physiology of increasing crop yields has led some observers to conclude that biotechnology could yield another generation of high-yielding varieties, which could again double or triple the yields of existing varieties. Unfortunately, traditional plant breeders have already done most of the things that are physiologically possible to raise the yield potential of the principal crops such as wheat, corn and rice. The main future contribution of genetic engineering to agriculture is likely to be disease- and insect-resistant plant varieties, but these will contribute to additional production only if they are more effective than the chemical controls now used.

Another area in which biotechnology might be able to contribute to greater production is the breeding of crop varieties that are more drought-resistant or salt-tolerant. In each of these cases, however, there may be some physiological constraints on how far genetic engineers can go. This is certainly true with increasing the water efficiency of crops, since water use is tied so directly to the basic physiological processes of plants such as photosynthesis, nutrient uptake and plant temperature regulation.

Some of the natural constraints on land productivity can be alleviated. For example, soil moisture can be increased by irrigation and soil fertility by fertilization. Indeed, one constraint, the availability of nutrients, has been eliminated in much of the world by fertilizer use. Between 1950 and 1998, world fertilizer use increased from 14 million to roughly 130 million tonnes, an increase of more than nine-fold. In many agriculturally advanced countries, fertilizer use is levelling off as the response to additional applications diminishes.

In looking ahead at the next 50 years, there is little potential for further increasing the share of photosynthate going to seed. World irrigated area is not expected to grow very much, if at all, since it seems certain to shrink in some countries. And world fertilizer use will continue to grow, albeit much more slowly, with the remaining growth concentrated in the Indian subcontinent, Africa and Latin America. The net effect of these conditions is that the increase in land productivity that has slowed so dramatically in the 1990s will probably slow further as the next century gets under way. Already some countries have experienced a plateauing or near plateauing of increases in yields, such as with wheat in the United States and rice in Japan. Some developing countries, such as Mexico with wheat and South Korea with rice, are also seeing their yield rises tapet off.

The risk for countries that are likely to become heavily dependent on grain imports for their food supply is perhaps greater than most realize, simply because the collective import needs of potentially grain-deficit countries promises to overwhelm the capacity of exporters. A little noticed change that affects the prospects for eradicating hunger is the levelling off since 1980 of grain exports among the principal exporting countries, which account for 85% of world exports. Some grain exporters will scarcely be able to satisfy their growing domestic

needs, while lack of soil moisture severely restricts the efforts of others to expand production.

The only major exporter that might be able to expand grain exports substantially is Argentina. Its current exports, running at around 20 million tonnes a year, could conceivably double. Still, this would be a rather minor increase in a world where the need for imported grain could easily jump from 200 million to 400 million tonnes in the decades ahead. One region not now contributing in a major way is Eastern Europe. Countries such as Poland, Ukraine, Hungary and Romania could expand their grain exports, at least modestly, if they adopted the economic policies needed to realize their full agricultural potential.

With the share of photosynthate going to seed already quite high and approaching the physiological limit in some situations, increasing yields becomes ever more difficult. The key question the world must now face is: Will the deceleration in the increase in grainland productivity that has been under way since 1990 continue, falling further and further behind population growth as we move into the next century?

Changing course

As we prepare for the new millennium, there is a rising tide of concern about long-term food prospects. Two major food issues face the world as it enters the 21st century. One is how to feed adequately those who suffer from chronic hunger and malnutrition, people who do not get enough protein and energy to develop their full physical and mental potential. The second is how to maintain the price stability needed in world grain markets if economic progress is not to be disrupted.

The worst mistake political leaders can make entering the new millennium is to underestimate the dimensions of the food challenge. To begin with, oceanic fisheries and rangelands – the two leading sources of growth in the animal protein supply over the last half century – have both apparently reached their limits. This means that all future growth in the world food supply must come from croplands, but irrigation water supplies may not expand much further and the response to additional fertilizer is diminishing in many countries. The backlog of unused technology to raise land productivity is shrinking. This does not mean that food production cannot be increased. It can be and it will. But sustaining the rapid growth needed to keep up with increased demand is becoming much more difficult.

Governments facing continuing population growth need to calculate their future population carrying capacity to provide the basis for a public dialogue on population policy. Societies can then consider what combination of population size and consumption levels they want, recognizing that there are trade-offs between the two.

Supply-side initiatives are still important in achieving an acceptable balance between food and people. But victory in the battle to eradicate hunger and malnutrition may now depend heavily on demand-side initiatives. The world still needs to invest more in agricultural research, in agricultural infrastructure, and in providing credit to small farmers, especially women in agriculture. But there is now a need for substantial demand-side initiatives to slow population growth and use grain and water more efficiently. Such initiatives should include:

- *Carefully articulated and adequately supported population policies.* The most recent UN population projections show the world adding 3.3 billion people by 2050, all of them in the developing world. Making sure that couples everywhere have access to family planning is one key step in achieving an acceptable balance between food and people. The cost of providing quality reproductive health care services to all those in need in developing countries is relatively small – about $17 billion in the year 2000 and $22 billion by 2015. Educating young females is a related key to accelerating a shift to smaller families. In every society for which data are available, the more education women have, the fewer children they have. Closely related is the need to provide equal opportunities for women in all phases of national life.
- *A move down the food chain for those who are consuming health-damaging quantities of fat-rich livestock products.* The healthiest people in the world are not those whose diets are dominated by livestock products, but those who consume them in moderation. In societies with a high incidence of obesity, such as the United States, a government-sponsored nutritional education programme to encourage the obese to eat less meat and other foods rich in fats could lighten pressure on world food supplies, improve health, increase life expectancy, and reduce health care costs.
- *Accelerate the shift to more efficient means of converting grain into animal protein.* With little prospect of increasing the animal protein yield of oceanic fisheries and rangelands, nearly all future gains must come from feeding, whether it be fish in ponds or cattle in feedlots. At this point relative conversion efficiencies come into play. For cattle in feedlots, an additional kilogram of live weight requires roughly 7 kilograms of grain. For pork, it is close to 4 kilograms of grain per kilogram of live weight. For poultry, it is just over 2; for the leading species used in fish farming, such as carp, catfish and tilapia, it is less than 2.
- *Using more water-efficient irrigation technologies and shifting to more water-efficient food staples.* The potential for developing new water resources is so limited that future gains in irrigation now depend more on increasing the efficiency of water use than on increasing supply. In some countries, for example, this may mean eating more wheat and sorghum and less rice. And since water efficiency in effect equals grain efficiency, responding to water scarcity also argues for encouraging the production of poultry and fish over beef and pork – trends that are already in evidence. If poultry and fish production are twice as grain-efficient as pork production, they are also twice as water-efficient since grain equals water.

Thus, restructuring the world water economy holds the key to eliminating hunger. One of the most frequently proposed remedies for water scarcity is water pricing: charging users enough for water to ensure that it is used efficiently. Although there is wide agreement among water analysts on the need to shift to this system, few governments have adopted effective water pricing policies. Water pricing would enhance the use of irrigation practices such as sprinklers, which can substantially boost efficiency over the traditional flood or furrow irrigation now widely used, especially in Asia. Drip irrigation, a technology pioneered in Israel, is not economical for use on grain, but on high-value fruit and vegetable crops it can cut water use by up to 70%.

Adequately feeding the projected increases in population poses one of the most difficult challenges that modern civilization faces. With little prospect of achieving an acceptable balance between food and people through supply-side initiatives alone, the time has come to focus on the demand side of the food equation as well. This means finding ways to accelerate the shift to smaller families, particularly in those countries where many are already hungry and malnourished, and it means that developing countries must avoid the unsustainable consumption patterns that have arisen in developed countries. It also means a significant change in food choices for those who are consuming unhealthily large amounts of high-input food products.

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Forest management in Tierra del Fuego: one more threat to the environment or an opportunity for sustainable development?

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Abstract

The possible impacts of a major forest management and furniture wood production scheme, proposed for the world's southernmost forests, have caused widespread concern. The attention given to the future of these pristine forests highlights the conflict between environmental protection/biodiversity conservation and economic benefits. Tierra del Fuego's public authorities and inhabitants are in a position to designate the lifestyles and environmental quality they desire, and to become involved in decision-making aimed at ensuring sustainability in ways suited to their social, economic and ecological conditions and expectations.

Résumé

Les impacts potentiels d'un vaste programme de gestion de la forêt et de production de bois d'ébénisterie proposé pour les forêts les plus méridionales de notre planète ont alarmé l'interêt public. L'attention portée à l'avenir de ces forêts vierges met en relief la difficulté de concilier protection de l'environnement, conservation de la biodiversité et interêts économiques. Les autorités publiques et la population de la Terre de Feu sont en position de décider de leurs modes de vie et de la qualité de leur environnement, et également de s'impliquer dans les décisions à prendre pour assurer un développement social, économique et environnemental durable, répondant à leurs attentes.

Resumen

Un importante proyecto de manejo forestal e industrialización de madera del bosque prístino más austral del mundo, excitó el interés público e instaló la controversia entre la conservación de la biodiversidad y los beneficios económicos de las inversiones. Este artículo explora cómo las autoridades y la población podrían tomar ventaja de la motivación experimentada para precisar los estilos de vida y la calidad ambiental deseada e involucrarse en decisiones hacia la sustentabilidad acordes a las condiciones y expectativas sociales, económicas y ecológicas insulares.

Introduction

At the southern tip of South America lies the archipelago of Tierra del Fuego ("Land of Fire"). It has borne this name since the time of the Portuguese explorer Ferdinand Magellan, when sailors discovered that there were fires on the Isla Grande (Large Island). These fires belonged to the aboriginal population. Today Argentina shares the island with Chile. The Argentine part (21,263 km²) has a population of around 90,000, mainly immigrants from continental Argentina. Some islanders are descended from European settlers. Most of the population lives in the cities of Río Grande and Ushuaia and the town of Tolhuin.

Tierra del Fuego's climate is cold and oceanic. The mean annual temperature is 5.5-6°C at sea level, ranging up to 8-10°C. The dominant natural vegetation consists of grassland in the drier northern part of the island, rolling country and low *fire* forests (*Nothofagus antarctica*) at the island's hilly centre; and tall *lenga* (*N. pumilio*) and/or *guindo* (*N. betuloides*) forests in the mountainous south. Differences in forest types are related to environmental factors; disturbances of natural and anthropogenic origin affect forests' structure and function (**Figure 1**).

The island experienced a population boom in the period 1975-88. The growth rate fell in 1988-91, but the population is again increasing rapidly. The northern and southern parts, isolated from one another by the Andes cordillera, have experienced different types of development. Río Grande, founded in 1921 and located in an area suited to sheep raising, has grown rapidly as the service centre of prosperous livestock activity. Oil and gas extraction are also important. In the last three decades there has also been substantial industrial growth.

Ushuaia, established by an Anglican church mission in 1869, became a maritime sub-prefecture of Argentina and *sede* of the Gobernación de Tierra del Fuego in 1884. It has always had an urban character and has long been devoted to administrative activities, with a prison and naval base. Today it is the provincial capital, a commercial and tourist port, and an industrial assembly site.

Ushuaia's population growth, from 7039 in 1976 to 40,870 in 1994, is due (like that of the entire island) to new employment opportunities resulting from tax exemptions. A special customs zone encouraged electronics and domestic appliance companies to locate there and to produce goods destined for the national market. The cost of housing increased, there was not enough housing to satisfy demand, and precarious construction began to spread unplanned around the city. This growth has impacted negatively on areas previously or recently deforested, which were without public services. Effects include polluted streams, the pushing back of the native forest, increased erosion, damage to bogs, and increased urban and industrial waste (including huge amounts of plastic packaging residues) that require more and more space for disposal. Environmental quality in neighbourhoods diminished, and a new social class arose with paradoxical signs of both wealth and poverty.

Earlier, the island's economy was based on the public sector, livestock raising on the northern grassland, selective logging (locally, *floreo*) of the best commercial *lenga* trees, and limited tourism in the Beagle Channel and Fuegian cordillera zone. Visitors were attracted by the scenic beauty and by fishing, skiing and other activities. In the 1990s, several new international category hotels were built behind and above Ushuaia on the mountain slopes, with spectacular views of the Beagle Channel, the city, islands and mountains covered with forest, and the high Andean grassland. The construction sites, roads, and ski run added new scars to the native ecosystems.

The economic challenges confronting Tierra del Fuego reflect the rapid changes occurring in the regional, national and international policy and economics arena. Tax exemptions are periodically re-analysed and it is intended to avoid them; competition from low-priced imported products on the national market have a destabilizing effect on companies; and social conflicts with unions occur. Several large *estancias* (ranches) have new foreign owners (individuals or companies). A profound debate has begun in Fuegian society concerning the island's future: What would happen if industry left? What if the forests were cut and the island lost one of its most important renewable resources and its pristine physiognomy, which are the basis of its economic activities and quality of life? What about biodiversity conservation under a new productive island scenario?

My view is that a sustainable future for the

Table 1
Favourable and unfavourable properties of interest for timber production in Fuegian *lenga* forests (modified from Richter and Frangi, 1992)

Favourable	Unfavourable
Mono- or bi-specific forests	Limited growth season
Mosaic of patches of different ages	High environmental heterogeneity
Patches of uniform structure	Unevenly aged stands
Low nutrient concentration in commercial wood	Very slow biological processes: net productivity, wood increment, decomposition
Micorrhizas and high resorption of nutrients	Frequent occurrence of fungus rotten wood
Shade mid-tolerance	Susceptibility to wind throws
Abundant seeds with high viability in most years	Three- to five-year periods with low seed production
High natural regeneration in sunny environments	Inadequate knowledge of biology, genecology of tree species
Absence of competitors	Damage to and killing of plantlings by native and introduced grazers
Succession of simple and predictable, scarce seral stages	Detrended succession by continued grazing on deforested areas
Wide range, low histeresis and malleability	Low elasticity

island rests mainly on its natural resource base. The main aim of sustainability is to balance short-term demand for goods and services against the persistence of ecosystems in the long term, ensuring similar opportunities to future generations. Sustainable systems can be conceived as combining: (1) profitable economic activity in which environmental variables are internalized (ecological economics); (2) socially equitable satisfaction of material, spiritual and aesthetic needs (a non-consumerist, more ethical society); (3) land restoration, use, transformation or conversion, consistent with environmental capacity and the ecological pre-adaptations of ecosystems and landscapes to continuous supply of goods and services without large subsidies for imported high-quality inputs (ecological management). The last point is considered highly dependent on the island's biodiversity – genetic, taxonomic and ecosystemic – and thus on the conservation of nature's basic structure and function. The sustainability concept should also help in the search for local models of ecodiversity in which culture, biology and ecology interact successfully to ensure the survival of the components in the long term.

In this framework, I will discuss the current controversy arising from a foreign company's proposal to manage a significant area of Fuegian forests, focusing not only on the specific project but also on the emerging lessons we should learn, or at least highlight as useful in designing a sustainable future for Tierra del Fuego.

Lenga ecology and management

In the Argentine sector, forests cover about 700,000 ha. About 510,000 hectares is *lenga* and *guindo* forests, of which approximately three-quarters is classified as productive.

As mentioned, ecological management is based on good awareness of the ecological properties of ecosystems. In our case, silviculture at stand level must take into account structural and functional properties and forest responses to stresses. Foresters should mimic natural factors in modifying forest structure in such a way as to produce favourable functional responses by ecosystems, including enhanced seedling production, better growth and health of desirable tree individuals, reduced competition, resistance to acute stress, and herbivore control. This must be done in partnership with the forest, avoiding replacement of components and processes the forest can provide spontaneously and without negatively affecting its ability to cope with the impact of management interventions.

The *lenga* forests have properties that are very important for timber management at stand and forest level (**Table 1**). These properties show that *lenga* wood and *lenga* forests have structural, functional and successional properties that allow their management for timber. However, wood production rates, irregular yearly seed production, and the possible impact of wind and biotic factors make the management planning stage enormously important. The impacts of wrong managerial decisions can affect several human generations.

The forest story

On 2 October 1994, *The Oregonian* (USA) announced that the Trillium Corporation of Bellingham was going "to the bottom of the world to turn up timber" from southern beech, a source of prime furniture wood. The newspaper mentioned the investments, the wood mill and manufacturing plant, and the job opportunities that would be created.

This article attracted the attention of the Argentine and Chilean press, NGOs and the public. Many magazines and newspapers highlighted the importance of the Fuegian forests and the need for caution; concerned environmentalists and groups of scientists asked for inventories and studies in order to prevent biodiversity loss and ecosystem deterioration. In Chile, the opinions of scientists and foresters were divided. The Rio Condor Project was addressed by the courts (Sentence N° 2732/96).

Lenga Patagonia S.A. and Forestal Trillium Ltd. are subsidiary companies of Bayside Ltd., which is part of the Trillium Corporation (Washington) and The Beacon Group (New York). The Rio Grande and Rio Condor Projects are twin projects for the management of 75,560 and 258,000 hectares, respectively, of Fuegian forests in Argentine and Chilean territory. In 1997, Lenga Patagonia S.A. submitted the Rio Grande project for approval by Tierra del Fuego's Argentine authorities.

The document is extremely interesting. For the first time on the island, a plan to manage forests and produce forest products locally had voluntarily made a commitment to sustainability. Its Stewardship Principles were designed to ensure equilibrium among economic, environmental and social components; a land steward was to be in charge of monitoring the fulfilment of these principles and keeping the public, government and company informed. Adaptive experimentation was to be the approach taken for continuous improvement of forest management. The project also included an environmental impact assessment and mitigation measures for silvicultural and harvesting activities, roads, the saw mill and industrial plant. With respect to biodiversity conservation, the company proposed designating natural reserves on its estates and asked the provincial government to accompany it by devoting additional public areas to this purpose. It also subscribed to the setting up of "aggregate retentions", or small forest plots undisturbed by man, and "disperse retentions", or scattered old-growth trees ("perching" trees), both to be left in the matrix of managed forest stands to permit natural evolution of ecological processes. Additionally, fringe forests and buffer zones would be preserved from logging, as established by local law.

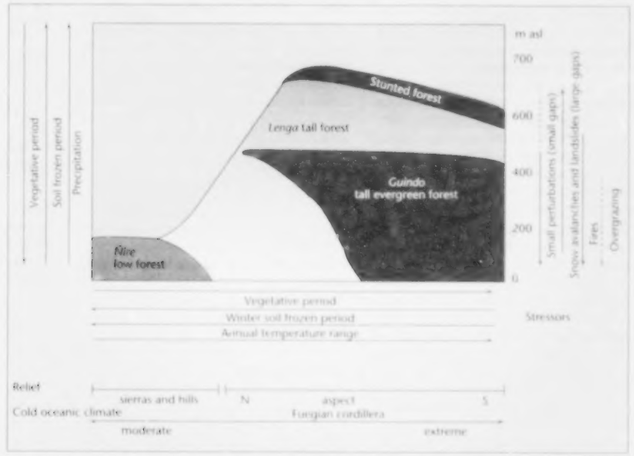
In May and June 1997, this document was examined by government officials and a group of international experts. The experts made criticisms of the forestry project, as they considered that it included a very optimistic estimate of the productive capacity of *lenga* forests and, consequently, that estimates of the volume and industrial production of wood would be impossible to meet in the forests' current state. Accordingly, the industrial project was overdimensioned and, if the suggested points were taken into account, needed to be restructured. In summary, there was not a satisfactory balance between the theoretical basis of sustainable management and biodiversity conservation and the proposal's technical level.

The evaluation also considered the management plan at stand and forest level. It suggested changes to specific proposals concerning the shelterwood method, in regard to natural disturbances and the trees' response to factors such as wind at different stages of forest development. Several problems were foreseen by foresters and ecological experts, who emphasized the need for a more detailed forest-level plan and recommended several additional measures in order to: reduce landscape homogenization; guarantee biodiversity conservation at different levels (genetic, taxonomic, ecosystem); avoid unnecessary damage to trees and other biota, or soil erosion in forests and wetlands, due to use of inadequate heavy machines, logging on steep slopes, failure to control herbivores, building of roads through sensitive ecosystems, or working under the wrong weather or seasonal conditions. They advised limiting *lenga* planting to reforestation sites where natural dispersion had been unable to establish genotypes in long abandoned areas.

Despite the proposal for land stewards, it was obvious that the government of the island would retain responsibility for controlling implementation of the environmental, forestry and social compromises agreed to by this or other foresters or forestry companies. A participative forum including concerned government agencies, local stakeholders and the forestry and scientific sectors was recommended.

In 1998, the timber company answered the questions put to it by provincial officers. Finally, the government considered that the project was in condition to start. At this point, however, local environmental activists initiated legal demands to impede logging. The issue is still being addressed by the courts at the time of writing.

Figure 1
Model of Tierra del Fuego's forest ecosystems



Acute and chronic stressors that influence forests' geographic distribution, structure and functions. Wind, not represented, is of importance all over the island. Windthrows depend on wind intensity, the trees' stage of development, and site characteristics (modified from Frangi and Richter 1992).

Emergent lessons

Several lessons resulted from the brainstorming that followed land acquisition for the Lenga Patagonia SA and the Rio Grande project. They include:

Lesson 1: New standards for forest management

The first lesson that emerged from the analysis of the Rio Grande project was that the requirements for sustainable management of Fuegian forests should be extended to all the island's productive *lenga* forests. This means the provincial government – in whose hands the larger part of the productive forests still rests – should establish new standards and conditions for the area annually authorized to be logged. It should be indicated that concessions are granted for the management of 700 to 1000 hectares of provincial forests annually, an area twice that recommended to be managed by Lenga Patagonia if the 110-year forest cycle is to be achieved within the available productive *lenga* forests on the company's estates. Management at stand level should obviously be considered in the wider context of the forest-level management plan and the concession holders' economic-technical capabilities. Moreover, for this and some of the following reasons the government should take advantage of the *Montreal Process* with the endorsement of the *Declaration de Santiago*. These documents provide a set of conservation and sustainable management criteria and indexes approved by the countries concerned with temperate and boreal forests.

Lesson 2: Biodiversity and conservation

Biodiversity conservation is currently limited to some essentially forested areas on the southern part of the island, including bogs, high grassland, lakes and ancient aboriginal sites. The Tierra del Fuego National Park is the main portion devoted to conservation. There are several provincial government projects to establish new reserves in forest areas, but apparently only experts foresee the need for a Magellan grassland reserve in the north and for more attention to grassland and shrubland management. At present, there is a commitment from the government and NGOs to develop a project for managing and conserving Patagonian marine coastal ecosystems. There is some interest in peat extraction from sphagnum bogs; the conflict in this case is between conservation of wetlands and the legal qualification of this extractive activity as mineral resource exploitation.

In other words, despite the increased importance given to forest protection areas as a result of governmental and private initiatives, it will be necessary to develop a more comprehensive plan for wilderness preservation of all the island's ecosystem heterogeneity, and to analyse the size of reserves and fragmentation and corridor issues. Conservation of ecotypes is very important for *Nothofagus pumilio* (and other southern beeches) because of the latitudinal range and heterogeneous environmental conditions in which they live. The issue should be analysed in cooperartion with Chile, as there is the possibility of establishing contiguous reserves in frontier areas in a way similar to what the two countries have done on the continent. In Chile, in fact, Forestal Trillium proposed the Kami Reserve on the frontier, just in contact with an area on Argentine territory where the provincial government wants to establish a provincial park.

Lesson 3: Tourism and recreational commitment to the environment

It is believed that tourism, especially ecotourism, will increase if the islanders protect Fuegian biodiversity. Today, national and international tourists arrive on the island to enjoy its marvellous natural scenery and facilities for trekking, fishing, skiing and other activities. It should be remembered that Ushuaias harbour is also the port for Antarctica. Moreover, the tourism industry supports nature conservation. I think this sector, including hotel owners, should internalize concern about conservation in its economic analysis (passive use values). The sector might help government funding of protected areas to be implemented, with all the infrastructure needed to enjoy and learn without losing natural resources. If the island has the choice of economic benefits with or without cutting forests or damaging wetlands, streams and lakes in several areas, I am sure the conservation-option will be successful. The government also needs to estimate the contribution of non-market values to sustainability, to be compared against the sustainable revenue from logging operations.

Lesson 4: Environmental education and stakeholder participation

Human behaviour is crucial for sustainability. Small and medium-sized islands are especially vulnerable to environmental misuse. Education is the means to promote favourable changes in human habits.

Currently, informal education is noticeably influencing popular knowledge about nature and environmentalism. Children – and adults too! – are more interested in learning through recreational activities than through formal education. Videos, tv programmes, interactive science and technology centres, and interpretative centres in conservation areas are examples of informal ways of increasing awareness of biodiversity conservation, deforestation, desertification, pollution, the ozone layer, resource consumption, climate change, and related global and sustainability-linked issues. This requires a frontal attack by governmental authorities and a true commitment expressed in actions, as well as greater participation by NGOs and other stakeholders.

Conclusion

The citizens of Argentina's youngest province have the opportunity to define what kind of lifestyle and environment they want. The Río Grande Project put one important issue on the table. Despite the particular final decision, however, it must be recognized that afterword there was a turning point in regard to public commitment to the environment. Perhaps it is time for stakeholders and government officials to accept together the challenge of searching for sustainable systems for the island.

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World News

Population and environmental issues studied

The world's population has tripled in the past 100 years and will reach six billion in 1999, according to the United States Census Bureau. This huge population surge, which has already had deep environmental impacts worldwide, may ultimately cause global transformations in our environment through climate change, diversion of water resources, and pollution. In a report entitled *World Population at a Glance: 1998 and Beyond*, the Census Bureau estimates that despite recent declines in fertility, the global population will be 8 billion by 2026 and 9.3 billion by 2050. The greatest increases are – and will continue to be – in developing countries, where water supplies, arable land and other natural resources are already under growing pressure. Developing countries will see 99% of the natural population increase (the difference between numbers of births and deaths), while deaths are expected to exceed births in the industrialized countries.

A sharp decline in mortality rates accounts for much of the population increase in the 20th century. Infant mortality, for example, has declined from 150 per 1000 live births in 1950 to only 58 per 1000 live births today. The drop is attributable mainly to advances in medicine and improved access to medical treatment. However, although life expectancy in many parts of the developing world is greater than it has ever been, it continues to be significantly less than in developed countries. The difference remains most striking in regard to infant mortality. While deaths of children of less than one year represent only 1% of all deaths in developed countries, they account for 20-25% of those in Sub-Saharan Africa, the Near East and North Africa. Many of these deaths can be attributed to environmental conditions, including diseases spread by unsafe drinking water.

Two demographic factors have somewhat slowed the global population increase. First, average birth rates in the developing countries have dropped dramatically, from over six births per woman in 1950 to slightly over three births today. The rate in a third of all countries is below the replacement level of 2.1 births per woman. Second, HIV/AIDS, especially in Africa and some Asian countries, has devastated many areas, with the majority of victims in their prime child-bearing and productive years. The report points out that the unpredictability of future childbearing trends, and of the spread and consequences of the HIV/AIDS pandemic, add considerable uncertainty to its forecasts. An increase in the availability of contraception could significantly reduce birthrates in developing countries.

Environmental effects and events can also have major effects on population growth trends. For instance, demographic patterns can be affected by famines caused by drought or natural disasters. Population-driven pressures, in turn, are already having major environmental impacts and are likely to continue to do so. The environmental load of pollutants, the use of non-renewable resources, and the destruction of natural habitats have all grown exponentially in the 20th century as the world's population has grown and increasing numbers of people have found themselves living in relatively industrialized, affluent societies. Environmental pressures can drive international migration, as populations leave areas where farmland has deteriorated, water supplies have dried up or forests have disappeared.

In response to concerns about the interrelated effects of population growth and environmental pressures, the heads of UNEP and the UN Population Fund (UNFPA) signed an agreement in April 1999 aimed at improving cooperation between the two programmes in areas related to sustainable development. The agreement will address the relationship between human well-being and population, natural resources and the environment. Stating that "population and environmental issues are interdependent and must be resolved as such," UNFPA Executive Director Nafis Sadik called for a holistic approach to the challenges of population growth. The agreement will cover three broad areas of cooperation: technical guidance and research; advocacy, public awareness, education and training; and strengthened coordination within the various UN inter-agency mechanisms. The agreement also responds to the call from member governments for improved effectiveness and cooperation within the UN system.

The University of Toronto's Project on Environment, Population and Security found that population-related impacts can have repercussions

The Kyoto Mechanisms: new market opportunities

The June 1999 *Swiss Derivatives Review* finds that the "market-based" mechanisms of the Kyoto Protocol on climate change – Joint Implementation, The Clean Development Mechanism and International Emissions Trading – could help turn a global environmental threat into new global business opportunities. Although the Protocol is not yet in force, companies are already examining the Kyoto Mechanisms' financial implications.

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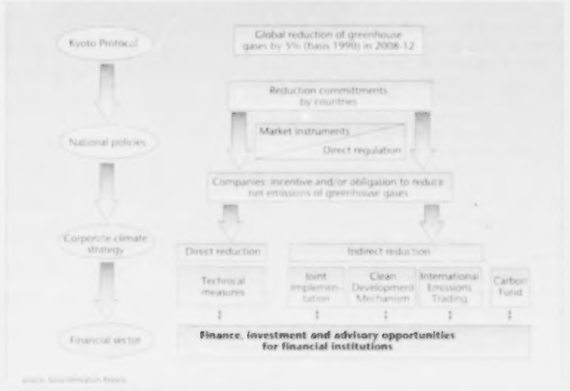


beyond environmental degradation. Its 1996 study concluded that environmental scarcity caused by degradation of, increased demand for, or unequal distribution of renewable resources can produce civil violence and instability. Although conflicts directly attributable to environmental scarcity are rare, scarcity generates social effects such as poverty and migrations that then appear to be a conflict's immediate causes. Environmental scarcity often encourages dominant population groups to attempt to control valuable environmental resources, while forcing marginal groups to migrate to ecologically sensitive areas. The study points out that societies can adapt to environmental scarcity through more sustainable strategies, either by using their indigenous environmental resources more efficiently or by reducing their dependence on these resources.

UNEP recently published a report, *Environmental Conditions, Resources, and Conflicts: An Introductory Overview and Data Collection*, highlighting the growing trend in international and civil conflicts that appear to be linked to deteriorating environmental conditions and resources. This report gives a concise overview of the elements of environment-related conflict as a basis for better understanding an increasingly complex field. Derived from a review of the scientific literature, it identifies three major trends. First, disputes over water resources seem to be a main source of direct international conflict. Second, indirect international or indirect intranational conflicts are commonly linked to resource depletion issues such as deforestation, soil erosion, desertification, flooding and pollution. Finally, the vast majority of environment-related conflicts apparently occur in developing regions.

These trends suggest that different means of conflict resolution and prevention may be appropriate, depending on the nature of the conflict. In the first two cases, water rights disputes or indirect conflicts caused by resources depletion, conflict could be prevented by giving priority to sound environmental and natural resources management. The transboundary nature of many of these issues may call for the involvement of international institutions, while resource management and stewardship will require the commitment and effort of governmental and non-governmental bodies and communities at both national and local levels. Countries' scientific, technical and social capacity to overcome deteriorating environmental conditions may be an important factor in addressing environmental conditions and reducing pressures that lead to conflict. Conflict resolution and prevention efforts should therefore be directed not only at improving environmental conditions, but also at increasing countries' capacity to mitigate environmental degradation.

The full text of the US Census Bureau's report is available at *www.census.gov/ipc/www/publist.html#PUB*. The Project on Environment, Population and Security study is available at *util2.library.utoronto.ca/www/pcs/eps.htm*. The UNEP report is available from Dr Ashbindu Singh, Regional Coordinator, UNEP Environmental Information, Assessment and Early Warning, EROS Data Center, Sioux Falls, SD 57198, USA. Tel: +1 (605) 594-6107/6117. Fax: +1 (695) 594-6119. E-mail: singh@edcmail.cr.usgs. gov. Internet: http://grid.cr.usgs.gov.

For more information, contact: US Census Bureau Public Information Office, Room 2705, FB-3, US Census Bureau, Washington, DC 20233, USA. Tel: +1 (301) 457-3030. Fax: +1 (301) 457-3030/3670. E-mail: pio@census.gov. Internet: http://www.census.gov; or the Peace & Conflict Studies Program at the University of Toronto, 5 King's College Circle, Toronto, Ontario M5S 3H7, Canada. Tel: +1 (416) 978 8148. Fax: +1 (416) 978-8416. E-mail: pcs.programme@utoronto.ca, Internet: util2.library.utoronto.ca/www/pcs/pcs.htm; or Maaike Jansen, UNEP Programme Officer, New York. Tel: +1 (212) 963-8151. E-mail: jansen@un.org. ◆

The Environment in France

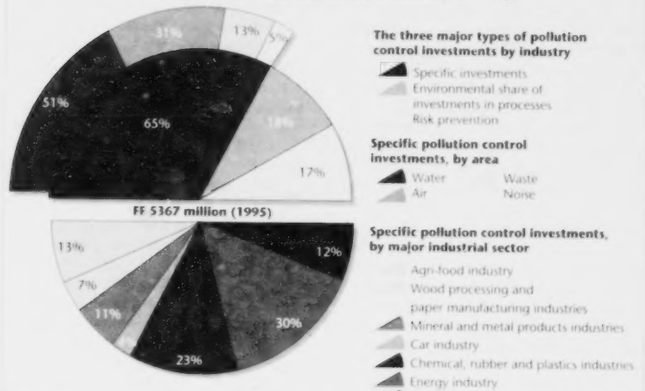
The French Institute for the Environment (IFEN), part of the French Ministry of Environment, has produced a report on the state of France's environment for the period 1994-1998. *The Environment in France* presents information on air and soil quality, marine and inland waters, land use, the natural heritage, and the urban environment. Environmental pressures include pollutant emissions, natural disaster risks and technological issues. The report describes the impacts of the agricultural, industrial, energy and transport sectors and gives an overview of actions taken by government at the local and national level, the EU, and citizens and NGOs.

The Environment in France describes the country's progress in improving the environment as real, but slower than many had expected. While most air and water pollutant emissions have declined markedly, for example, two-thirds of all waste is still landfilled and most incineration plants do not meet dioxin emissions standards. The report identifies the same mix of progress and setbacks in land use planning, citing increased urban sprawl and some deterioration of the rural environment. But it notes that recent coordination of government responsibility for spatial planning and the environment has created an opportunity for improvement in these areas.

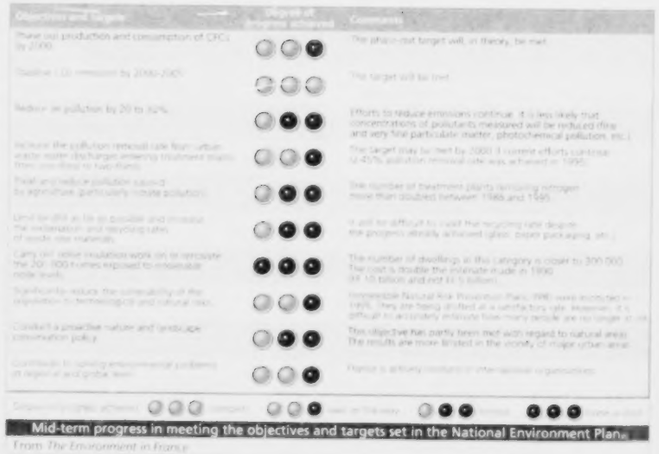
The report is available in a full-length French language version and in an abridged English language version. Features unique to the English version include a glossary of the main public institutions in France that produce environmental information, as well as an organizational chart detailing the French environmental administrative structure. Both versions can be ordered from IFEN.

For more information, contact: IFEN, 61 bd. Alexandre Martin, 45058 Orléans Cedex 1, France. Tel: +33 (2) 38 79 78 78. Fax: +33 (2) 38 79 78 70. E-mail: ifen@ifen.fr. Internet: www.ifen.fr. ◆

Environmental protection expenditure by industry



From *The Environment in France*



Mid-term progress in meeting the objectives and targets set in the National Environment Plan

From *The Environment in France*

Nigeria publishes National Agenda 21 and National Policy on the Environment

The Nigerian Federal Environmental Protection Agency (FEPA) has produced a National Agenda 21, with the goals of integrating environmental considerations into development planning and speeding the transition to sustainable development. Based on Agenda 21, the global initiative for sustainable development adopted at the 1992 UN Conference on Environment and Development in Rio de Janeiro, the document addresses sectoral priorities and strategies for major sectors of the economy, as well as regional and international cooperation in pursuing environmental and sustainability goals. The programmes and issues addressed cover a wide range, from poverty alleviation to waste management. For each issue, a mission statement, detailed objectives, information on current programmes and activities and the responsible local and national government bodies are included.

FEPA has also published a new edition of the National Policy on the Environment. While the overall goal is sustainable development, this policy document details policies and implementation strategies for air and water pollution control, natural resources management, social and health issues, and trade and tourism. It includes strategies for responding to natural disasters, drought, desertification and erosion. This document also addresses institutional and governmental issues and financing considerations, including the use of economic instruments in managing environmental and natural resources.

For more information, contact: FEPA, The Presidency, Independence Way South, Central Area, Garki-Abuja, Nigeria. Tel: +234 (9) 523-3379. ◆

Developing countries can reduce emissions and improve their economies at the same time

A new report shows how developing countries can reduce air emissions from power generation without sacrificing economic growth. Prepared by the Pew Center on Global Climate Change, *Developing Countries and Global Climate Change* outlines four strategies to decrease CO_2 and other emissions that contribute to global warming. The levels of these emissions are expected to triple in the next 20 years, to 10% of all global emissions, if present trends continue.

The report examines the costs and benefits of using natural gas and renewable energy sources for power generation and privatizing state-run power monopolies. It finds that renewable energy options were economically viable when electricity delivery costs were considered part of the costs of electricity generation. Increased use of natural gas and renewable energy sources would reduce CO_2 emissions by almost 25% over current energy sources. The report predicts that privatization would slightly reduce CO_2 emissions and increase overall economic benefits, while improving the efficiency of electricity supply and demand could reduce CO_2 emissions by as much as 10%.

This study is based on an aggregated analysis, and its authors warn that the results may not be applicable to all countries. They note that countries could also participate in the Clean Development Mechanism, in order to increase available financing to accomplish necessary, country-specific reforms.

The Pew Center's next step in this ongoing project is to conduct detailed follow-up case studies on power generation in Argentina, Brazil, China, India and South Korea.

For more information, contact: Pew Center on Global Climate Change, 2111 Wilson Blvd., Suite 350, Arlington, VA 22201, USA. Tel: +1 (703) 516-4146. Fax: +1 (703) 841-1422. Internet: www.pewclimate.org.

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Industry Updates

US subsidies considered to undermine recycling

A report by a group of American environmental organizations says government studies in the United States discourage recycling. The report, *Welfare for Waste: How Federal Taxpayer Subsidies Waste Resources and Discourage Recycling*, was written by the GrassRoots Recycling Network, Taxpayers for Common Sense, the Materials Efficiency Project, and Friends of the Earth. It has been endorsed by a number of other environmental and recycling groups. Fifteen government subsidies for the timber, mining, oil, energy and waste disposal industries are listed. According to the authors, these subsidies lower the cost of products made from new materials, giving them a competitive advantage over those made from recycled materials. They state that federal subsidies, which may amount to as much as US$ 15 billion over the next five years, "are part of a complex system of economic preferences discouraging recycling."

The system of tax and spending subsidies was created decades ago, at a time when natural resources seemed limitless. They include indirect subsidies, such as cheap energy that disproportionately benefits energy-intensive extractive industries; road-building at taxpayer expense, to serve industries remote from metropolitan markets; and tax policies that favour capital expenditures over labour costs. Externalized costs often paid by taxpayers, rather than by the virgin materials and waste disposal industries, include environmental impacts, pollution clean-up and waste disposal.

In response to the report, a coalition of 116 business, environmental and recycling groups has called on the US Government to end such subsidies. They point out that including the full, unsubsidized costs of materials and products in their pricing could aid recycling and reuse industries and spur more efficient product design and manufacturing. Recycling and reuse generally consume materials, energy and water more efficiently and produce less pollution than virgin materials industries. The coalition calls for a materials efficient policy that includes the following elements:

◆ a cut in direct federal subsidies for virgin materials industries;
◆ investigation and reform of state and local subsidies to save taxpayers money while promoting materials efficiency;
◆ government examination of indirect federal subsidies, such as those for energy and transportation, and others that negatively affect materials efficiency;
◆ a public review to determine policies to develop a materials-efficient economy that requires fewer taxpayer subsidies.

The coalition plans to lobby the US Congress to reduce subsidies and promote materials efficiency – and to start by recycling the waste produced in the Congress's own operations.

For more information, contact: Lance King, GrassRoots Recycling Network, PO Box 49283, Athens, GA 30604, USA. Tel: +1 (703 582 7932), Internet: www.grrn.org.

Silicon Valley group calls for mandatory computer recycling

An environmental group in the US's Silicon Valley has called for mandatory recycling of old computers and related equipment. The world is rapidly accumulating "mountains of obsolete computer junk," points out the San Jose-based Campaign for Responsible Technology, which is promoting an initiative to hold American computer manufacturers responsible for recycling their own products. The proposal is similar to one being considered in the European Union.

The group says the computer disposal problem is worsened by the computer industry's "planned obsolescence" policy of frequently introducing upgraded products, while the rate of recycling has decreased in recent years due to a lack of effective systems or policies. Electronic equipment and waste are typically dumped in landfills, incinerated or shipped to China, where they are disassembled and then burned. The group's coordinator, Ted Smith, stresses that these methods can all release toxic substances, including plastics, lead, mercury and solvents, into the environment. The group calls for a life-cycle perspective in the design of new products, and for government and corporate policies to internalize the costs of disposal and guarantee the return and safe disposal of all used products.

For more information, contact: Ted Smith, Campaign for Responsible Technology, c/o Silicon Valley Toxics Coalition, 760 North First Street, San Jose, CA 95112, USA. Tel: +1 (408) 287-6707, E-mail: srtc@igc.apc.org, Internet: www.svtc.org/svtc/crt.htm. ◆

UNEP Focus

Governments seek faster phase-out of CFC production

Representatives of 110 governments and 35 NGOs met in Geneva in June 1999 to find ways to speed up elimination of chlorofluorocarbons (CFCs) and halon compounds, which damage the Earth's ozone layer. A major topic of discussion at the 19th meeting of the Open-Ended Working Group of the Montreal Protocol on Substances that Deplete the Ozone Layer was replenishment of the Multilateral Fund, which helps developing countries meet their starting commitment to phase out CFCs and halons. The fund, established in 1990, has approved some US$ 900 million to support projects aimed at phasing out 117,000 tonnes of CFC production – equal to 60% of developing country consumption.

Under the Montreal Protocol, developing countries must reduce their production to 1995-97 average levels starting 1 July 1999. Then they must cut back rapidly to 50% by the year 2005, phasing these chemicals out entirely by the year 2010. The Multilateral Fund has allocated funds to help China, the world's largest producer of CFCs and halons, close down its production facilities for these chemicals by the 2010 deadline. It is negotiating with India, which has the second largest production capacity among developing countries, to develop a programme to close its production facilities.

The Protocol's Technology and Economic Assessment Panel earlier set up a special Task Force to assess CFC growth rates in the baseline period 1995-97. The Task Force found that these growth rates were significantly lower than expected. The 2000-02 replenishment of the Fund could therefore be set at US$ 806 million, significantly lower than the $465 million allocated for 1997-99, to comply with the Protocol's minimum requirements for a freeze on CFC and halon consumption. However, the task force recommended a replenishment level of $500 million to continue the phase-out momentum for the period 2003-05.

The Working Group considered proposals by the European Community to advance the phase-out schedule for hydrochlorofluorocarbons (a leading CFC replacement), introduce trade controls on methyl bromide, and control new ozone-depleting substances emerging from research laboratories. No agreement was reached on the proposals, which will be further considered at the Meeting of the Parties in Beijing in December 1999.

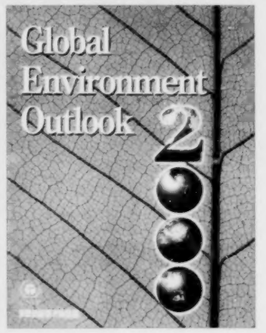
The Scientific Assessment Panel presented a report prepared jointly with the Intergovernmental Panel on Climate Change, Aviation and the Global Atmosphere, which assesses aviation's impact on ozone depletion and climate change. The report concludes that aircraft emissions will increase to 5% of all greenhouse gas emissions by 2050 (compared to 3.5% in 1992) unless they are controlled. The impacts would be most significant if a large fleet of supersonic aircraft went into service in the coming century.

The meeting took place amid growing concern that global warming may already be making ozone depletion worse than predicted. Greenhouse gases that trap heat in the lower atmosphere near the Earth's surface prevent heat from escaping into the lower stratosphere, where the ozone layer is located. The resulting lower temperatures can accelerate the chemical processes that destroy ozone. Reports presented by the 1998 panels on the assessment of the ozone layer, and on environmental impacts and technological and economic aspects, showed that the total amount of chemicals in the lower atmosphere has peaked, though some gases such as halons are still increasing. The Working Group concluded that recovery of the ozone layer will be observable over the next two decades if the Protocol is fully implemented by all the countries.

The report of the meeting, as well as other information, is available on the Internet at www.unep.org/ozone or www.unep.ch/ozone.

For more information, contact: Tare Brevik, UNEP Spokesman. Tel: +254 (2) 623292, E-mail: tare.brevik@unep.org, or Rajendra Shende, UNEP TIE Paris, OzonAction Programme. Tel: +33 (1) 44 37 14 59, E-mail: rajendra.shende@unep.fr. ◆

UNEP's Global Environment Outlook 2000



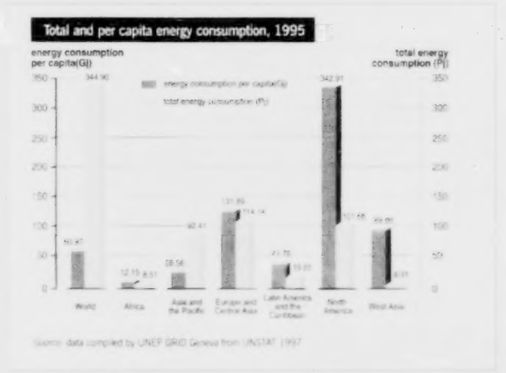
With the publication of its *Global Environment Outlook 2000* (GEO-2000) report, UNEP has produced an authoritative assessment of the world's environmental crisis. The report is based on contributions from UN agencies, 850 individuals, and more than 30 environmental institutes. GEO-2000 analyses global and regional issues, examining the current state of the environment, the policy responses governments are using to address environmental issues, and the outlook for the future.

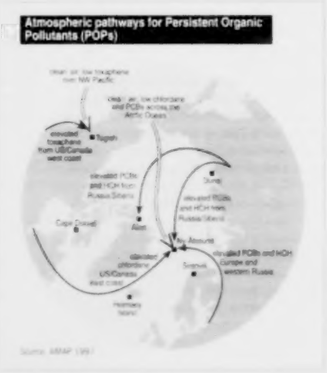
The report finds that full-scale emergencies now exist in a number of areas, from the capacity of the world water cycle to cope with demands in the coming decades to the widespread land degradation and desertification that inhibit agricultural productivity. Crisis-level air pollution has become a daily occurrence in many major cities, and global warming related to ever-increasing emissions of carbon dioxide (CO_2) and other greenhouse gases now seems inevitable. Many of the other issues raised by the report are equally well-known: ozone depletion, high non-renewable energy consumption, loss of biodiversity, and the risks of using chemicals including persistent organic pollutants (POPs). But GEO-2000 also discusses new environmental concerns such as:

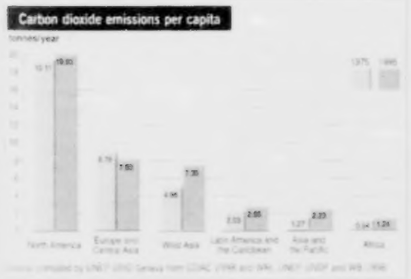
◆ nitrogen's harmful impact on ecosystems;
◆ the increased severity of natural disasters;
◆ species invasion as a result of globalization;
◆ increased environmental pressures caused by urbanization;
◆ a decline in the quality of governance in some countries;
◆ new wars which impact on both the environment of the conflict area and that of neighbouring states;
◆ the impact of refugees on the natural environment.

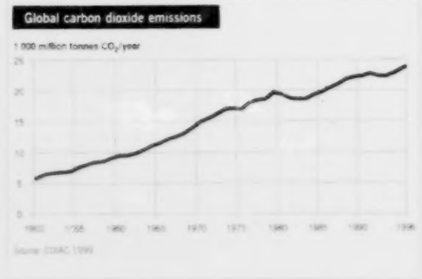
GEO-2000's key finding is that "the continued poverty of the majority of the planet's inhabitants and excessive consumption by the minority are the two major causes of environmental degradation. The present course is unsustainable and postponing action is no longer an option." The report outlines progress in tackling existing problems, and concludes with recommendations for immediate, integrated action.

GEO-2000 was published by Earthscan Publications on behalf of UNEP. It is available from Earthscan, Tel: +44 (171) 2780433, Fax: +44 (171) 2781142, E-mail: earthinfo@earthscan.co.uk, or from UNEP, E-mail: geo@unep.org, Internet: www.unep.org/geo2000.









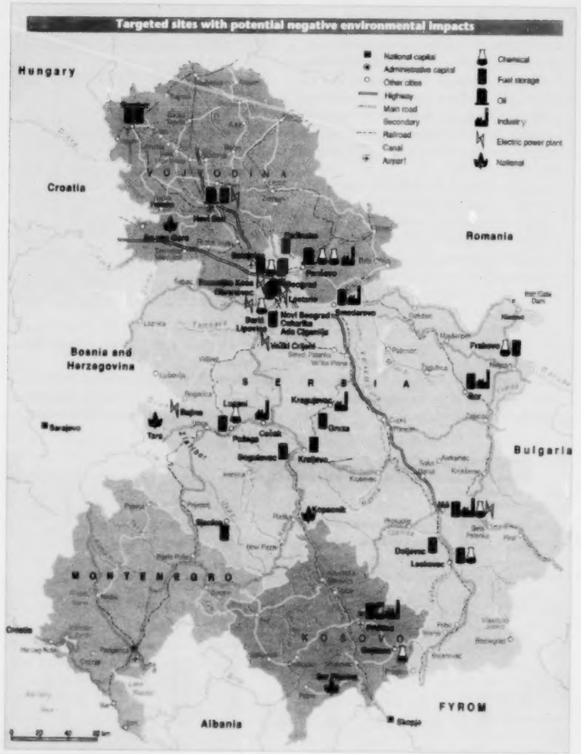
UNEP/Habitat task force monitors environmental damage in the Balkans

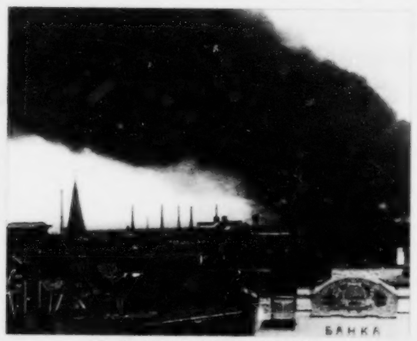
UNEP and the UN Centre for Human Settlements (Habitat) have established a task force to assess and track environmental and human settlement impacts of the conflict in the Balkans. The purpose of the Balkans Task Force (BTF) was to gather and review information on impacts on human settlements and actual and potential environmental impacts in the Federal Republic of Yugoslavia and neighbouring countries. In cooperation with technical bodies and other UN agencies, it identified areas in need of assistance, formulated response measures, and made recommendations on response actions. The former Environment and Development Cooperation Minister of Finland, Pekka Haavisto, served as chairman.

As a first step, a UNEP representative travelled to Serbia, Kosovo and Montenegro in May 1999 with a UN inter-agency humanitarian mission to begin assessing the damage. This mission reported that numerous civilian industrial facilities had been destroyed by the NATO air campaign. It cited damage to oil refineries, fuel dumps, and chemical and fertilizer factories. The initial mission report stated that many of the compounds released from these facilities can cause cancer, miscarriages, birth defects, and fatal nerve and liver diseases.

UNEP and Habitat experts visited the region again in June and returned beginning in July to undertake a full-scale environmental assessment of the sites identified. A team of BTF scientists visited the Pancevo industrial complex, the Novi Sad oil refinery, and various other industrial sites. Using a mobile laboratory, they analysed soil and water samples for toxic chemicals such as dioxins and chlorine compounds. They also held meetings with environmental experts, representatives of local NGOs, and local authorities. Another team focused on environmental impacts on the Danube River, checking potential pollution "hot spots" near Pancevo and Novi Sad, a tributary near the Zastava car factory in Kragujevac, and the Iron Gate dam on the Yugoslav-Romanian border. A third team assessed the damage to biological diversity in protected areas in Serbia and Montenegro, including Fruska Gora National Park near Novi Sad, Kopaonik National Park, Zlatibor, and Lake Skadar in Montenegro. Approximately 4% of Yugoslavia's land is classified as protected natural areas.

As part of UNEP's Kosovo response effort, another BTF team worked with the UN Mission in Kosovo to create mechanisms for land title registration, resolve tenancy and property disputes, and strengthen municipal (including environmental) administration and leadership.





Smoke cloud over Pancevo, April 1999

Following the field work, BTF scientists and experts analysed the data and prepared a report documenting the concerns identified and giving recommendations on response actions. The BTF report concludes that although the Kosovo conflict did not cause a widespread environmental catastrophe, serious pollution detected at four environmental hot spots (Pancevo, Kragujevac, Novi Sad, and Bor) posed a threat to human health. These sites were contaminated with chlorine compounds, dioxin, oil and heavy metals, including mercury. Damage at Bor, an ore smelting facility, caused continuing atmospheric releases of large amounts of sulphur dioxide. The report calls for immediate clean-up action at these sites, all located in Serbia. It also concludes that much of the pollution identified occurred before the conflict began, and that there have been long-term deficiencies in hazardous waste treatment in many areas.

The effects of the conflict on biodiversity were found to be significant within limited areas, but relatively minor in relation to the overall size of the protected areas and the ecosystems surrounding the air strike sites. A more serious concern is unexploded ordnance, which remains both an immediate safety issue and a possible long-term constraint on tourism in the National Parks and wildlife areas.

With regard to the human settlement problem in Kosovo, the BTF noted that it cannot be resolved just by reconstructing houses, but must also be addressed through administrative procedures that will give people security of tenure. Providing housing to returning refugees is complicated by the collapse of municipal administrative systems, including the loss of all property records. Kosovo also lacks a legislative and policy framework on housing and property that meets accepted international standards.

Based on the BTF's findings, and in consultation with the European Union, individual European countries and NGOs, UNEP has recommended that environmental ... 2 be incorporated into the humanitarian aid effort in the Balkans. "As part of the humanitarian aid to the region, the international community should assist the relevant authorities in dealing with the key environmental hot spots, thus avoiding further harm to human health and the environment in Yugoslavia and the wider Balkans region," said Haavisto. "Although the Yugoslav government, which has the main responsibility for clean-up efforts, can deal with some of the priorities we've identified, others will require assistance from the international community."

Altogether, some 60 experts from six UN agencies, 19 countries and 26 scientific institutions and NGOs were involved in the various BTF assessment missions. The work was funded by voluntary contributions from Austria, Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden and the United Kingdom. In-kind support was provided by Russia, Slovakia and several NGOs, including Greenpeace, the World Wide Fund for Nature, the World Conservation Union, Green Cross and the World Conservation Monitoring Centre.

Complete information on the BTF mission and its findings is available on-line at www.grid.unep.ch/btf. The site includes maps and detailed situation reports. The full report is available through UNEP's on-line bookstore at www.earthprint.com, or from SMI (Distribution Services) Limited, PO Box 119, Stevenage, Hertfordshire SG1 4TP, UK, Fax: +44 (1438) 748 844.

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South Pacific islands develop regional strategy to meet Montreal Protocol requirements

Eight island countries from the South Pacific met in Geneva in June 1999 to decide on a regional strategy for implementation of the Montreal Protocol. This meeting was held in conjunction with the Open-Ended Working Group meeting (see above). Representatives of Fiji, Kiribati, the Marshall Islands, the Federated States of Micronesia, Papua New Guinea, the Solomon Islands, Tonga, Tuvalu, Vanuatu and Western Samoa discussed plans for a regional phase-out strategy for ozone-depleting substances (ODS). The issue is critical for these countries because of their economic dependence on the fishing and tourism industries, which rely heavily on refrigeration and air conditioning. ODS are commonly used in cooling systems.

"Though our consumption of ODS is insignificant compared to large countries," said Kenneth Bulehite, the Solomon Islands' National Ozone Officer, "it is crucial that we phase-out these substances early to ensure continuous supply of the alternatives that are essential in our fisheries and tourism industries."

Participating countries will develop country-level action plans. The regional strategy is to identify elements of these plans that can be implemented cost-effectively and rapidly at the regional level, and to coordinate their implementation. Implementation is expected to occur over a three-year period. The programme will also assist non-Party countries with their ratification of the Protocol and inclusion in the regional implementation plan. The Cook Islands, Nauru, Niue and Palau have expressed interest in participating.

This meeting, the first among Pacific small island countries to address implementation, was sponsored by UNEP, the Government of New Zealand and the South Pacific Regional Environment Programme.

For more information, contact: UNEP TIE, Paris, Ozonaction Programme. Tel: +33 (1) 44-37-14-50, Fax: +33 (1) 44-37-14-74, E-mail: ozonaction@unep.fr.

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UNEP/Canon photo competition

UNEP and Canon, Inc. are sponsoring the third International Photographic Competition on the Environment. The "Focus on Your World" competition aims to raise global environmental awareness and to document the state of the world's environment through photographs. Entries from both professional and amateur photographers, of all ages and nationalities, are invited. The previous competitions have drawn some 75,000 entries. Exhibits of the winning photos have been shown in major cities around the world.

Entrants are encouraged to give visual expression to their hopes and fears for the planet and the human struggle for sustainable development. Photographs may focus on the beauty and wonder of our natural environment, or depict the fragility and damage caused by unchecked development.

"On our difficult journey towards sustainable

"Holding on to life", a prize-winning photo from the 1995 UNEP/Canon competition (Tom Stockdart, UK)

development, we need a common language, a language that can instantly touch hearts and minds," said Klaus Töpfer, UNEP's Executive Director. "Photography is that common language, one that gives life, colour, expression, a human touch to our scientific findings, our myriad of facts and figures. Photography, in itself a creative act with which to convey environmental messages, can provoke, can stimulate, leading to positive action and change. 'Focus on Your World' is not only a slogan for UNEP's successful photo competitions, it is a call for pause, for each of us to reflect upon our environment and our common future."

The competition has two categories, adult and junior divisions. Gold, silver and bronze prizes, and an honorary mention, will be awarded in each division. The gold prize winner in the adult division will receive US$20,000. The junior division winner will receive $2000. Winners will receive cash and diplomas, with Canon products as supplementary prizes. Other special prizes from UNEP and Canon include a scholarship from the International Photographic Council as well as a digital camera.

"Canon is determined to excel as a truly global corporate group, contributing to the world through our philosophy of kyosei – living and working for the common good," said Fujio Mitarai, President of Canon, Inc. "We share UNEP's strong belief that these activities must be more than just a passing fad. To this end, we are delighted to continue our support."

The competition will run until 30 April 2000. Photos must have been taken between 1 January 1999 and 30 April 2000. Winning photographs will be selected in June 2000 by a panel of expert international judges, and the awards ceremony will be held in New York in conjunction with the United Nations Millennium Assembly in September 2000.

Entry forms are available from UNEP and include a list of addresses around the world to which entries can be submitted. The competition also has its own web site (www.unep-photo.com), from which entry forms can be downloaded.

For additional information and entry forms, contact: Tore Brevik, Spokesman and Director of Information, Communications and Public Information, UNEP, PO Box 30552, Nairobi, Kenya. Tel: +254 (2) 626292, Fax: +254 (2) 623692, E-mail: tore.brevik@unep.org; or Steve Jackson, Audi[illegible]ual Officer, UNEP, Nairobi. Tel: +254 (2) 623332, Fax: +254 (2) 623332, E-mail: photocon.96@unep.org. ◆

UNEP TIE HIGHLIGHTS

Asian countries will limit trade in hazardous chemicals

Representatives of 17 Asian countries met in Bangkok in June to discuss limitation trade in certain hazardous chemicals and pesticides. The purpose of the meeting was to identify steps they must take to implement the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. Parties to the Convention agree not to export 27 harmful pesticides and industrial chemicals that have been banned or restricted (especially those causing problems because of the way they are used in developing countries) unless the importing country agrees to accept them. It also requires a country attempting to export a chemical that is banned or restricted on its own territory to inform the importing country before the first shipment and then annually. The requirements allow exporting and importing countries to share the responsibility for notification and monitoring, in their effort to prevent adverse effects on human health and the environment from these chemicals.

The Convention was adopted in Rotterdam in September 1998 and was initially signed by 61 countries. It will enter into force once it has been ratified by 50 countries. The Convention incorporates the Prior Informed Consent procedures that 154 countries have undertaken voluntarily since 1989. UNEP and the Food and Agriculture Organization (FAO) jointly operate the Interim Secretariat that supports governments in its implementation.

Commenting on the Bangkok meeting, James B. Willis of UNEP, Executive Secretary for the Rotterdam Convention, said: "How countries respond to the challenge of implementing the new agreement will shape the future public health and environmental safeguards that communities around the world receive from trade in highly dangerous chemicals and pesticides."

The Asian region workshop was the first to promote implementation and ratification and to inform national authorities about the Convention's obligations. Such information is essential to the Convention's implementation. Participating countries (which include Bangladesh, Bhutan, China, India, Indonesia, Japan, Korea, Laos, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Viet Nam) identified needs for implementing the Rotterdam Convention, including national enforcement legislation and strengthened infrastructure. The proceedings, now available in report form, contributed to the sixth session of the Intergovernmental Negotiating Committee working under the new global agreement on trade in hazardous chemicals and pesticides on 12-16 July 1999 in Rome.

Substances subject to the Convention's requirements include the pesticides 2,4,5-T, aldrin, captafol, chlordane, chloridmeform, chlorobenzilate, DDT, dieldrin, dinoseb, 1,2-dibromoethane (EDB), fluoroacetamide, hexachlorocyclohexane (HCH), heptachlor, hexachlorobenzene, lindane, and mercury compounds, and certain formulations of monocrotophos, methamidophos, phosphamidon, methyl-parathion, and parathion. Industrial chemicals included in the Convention are crocidolite asbestos, polybrominated biphenyls (PBBs), polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs), and tris (2,3 dibromoprophyl) phosphate.

Copies of the report of an earlier meeting, the Subregional Awareness Raising Workshop on the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade which took place in Bangkok on 8-11 December 1998, are available from UNEP Chemicals in Geneva and FAO in Rome. Official documents and other information on the PIC procedure and Rotterdam Convention are available on the Internet at www.pic.int.

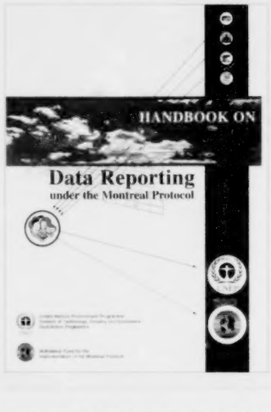
For more information, contact: James B. Willis, UNEP Chemicals. Tel: +41 (22) 917 81 83, Fax: +41 (22) 797 3460, E-mail: pic@unep.ch; or, Niels Van der Graaff, FAO, Plant Protection Service, Plant Production and Protection Division. Tel: +39 (6) 5705 34 41, Fax: +39 (6) 5705 63 47, E-mail: pic@fao.org. ◆

Handbook on Data Reporting under the Montreal Protocol

UNEP TIE's OzonAction Programme has prepared a new publication to assist developing and developed countries to provide the information required under the Montreal Protocol, the treaty on protecting the stratospheric ozone layer from the effects of ozone depleting substances (ODS). Accurate, comprehensive, and timely data on the production and consumption of ODS are essential to the success of the Montreal Protocol process, enabling decision-makers at the national, regional and international levels to formulate appropriate control measures, devise realistic phase-out strategies, and give financial and technical assistance to developing countries. The *Handbook on Data Reporting under the Montreal Protocol* provides guidance for identifying a country's reporting obligations; outlines approaches for collecting the necessary data and checking data for accuracy, consistency, and compliance; indicates how and when to furnish data to the UNEP Ozone Secretariat and Multilateral Fund Secretariats; lists sources of further information; and includes copies of key forms required for data reporting.

The hard copy version is available in six languages (Arabic, Chinese, English, French, Russian and Spanish), and the full text of the document is accessible free-of-cost through the OzonAction Programme's web site at www.unepie.org/ozonaction.html. The Handbook can be ordered from SMI (Distribution Services) Limited, P.O. Box 119, Stevenage, Hertfordshire SG1 4TP, UK, Fax: +44 (1438) 748 844.

For more information, contact: UNEP TIE, Paris, OzonAction Programme, Tel: +33 (1) 44 37 14 50, Fax: +33 (1) 44 37 14 74, E-mail: ozonaction@unep.fr.



UNEP TIE on the web

UNEP's Cleaner Production (CP) newsletter is now available on the Internet at *www.unepie.org/cp2*. The latest issue features articles on:

- Strategies and mechanisms for promoting CP investments in developing countries. This project, which helps financial institutions and companies understand the benefits of cleaner production investments, currently has pilot projects in five developing countries.
- The UNEP Declaration on Cleaner Production. A new section on the CP web page provides support for current and future signatories, as well as news and information on upcoming events.
- CP developments around the globe, including in India, Croatia, Zambia and Denmark.

The CP web pages are located on UNEP TIE's web site, the home page for all TIE activities is *www.unepie.org*. The CP web pages also include reports on past CP activities, and information and schedules for upcoming events. The Cleaner Production newsletter, like all UNEP TIE publications, is available in hard copy from TIE's Paris office.

UNEP and the tourism industry develop initiative for sustainable tourism

In June 1999, UNEP's Division of Technology, Industry and Economics hosted the first meeting of tour operators to develop the Tour Operators Initiative for Sustainable Tourism Development. The initiative, co-sponsored by UNEP, the World Tourism Organization and UNESCO, commits its participants to reduce the negative environmental and social impacts of tourism while developing and managing it in ways that contribute to sustainable development.

The tourism industry accounts for almost 11% of the world gross domestic product. It is one of the world's largest industries, with more than 260 million employees and annual capital investments of more than US$800 billion. It plays a crucial economic and developmental role in many developing countries. The Initiative recognizes the importance of tour operators in the industry's growth, often determining where tourists go and the facilities they use. While most tour operators understand that a clean and protected environment is crucial to their success, relatively few have incorporated environmental management policies into their business practices.

The UNEP meeting's participants included 14 tour operators and representatives from NGOs, industry associations, and national and local public authorities. They drafted a statement of commitment, to be signed by members of the Tour Operator Initiative, and formed working groups that will finalize the statement, develop a programme to help members with implementation, promote the initiative, and work out the details of organizational, membership and funding procedures.

Klaus Töpfer, UNEP's Executive Director, and several tour companies announced the Initiative during the seventh session of the Commission on Sustainable Development (CSD-7) in April 1999. CSD-7 also hosted a dialogue among representatives of the tourism industry, national and local governments, trade unions and activist groups on how to benefit from the fast-growing tourism industry without damaging the environment and undermining local communities. Following the discussion, the first of its kind at a CSD session, the Commission adopted an action plan incorporating participants' ideas. The action plan urges governments to develop national strategies or master plans for sustainable tourism, and to work in partnership with the tourism industry and other major groups, especially at the local level. Specific suggestions include a proposal that airlines screen in-flight videos to educate tourists about the environmental and cultural sensitivities of their destination.

The tourism industry already has some voluntary schemes in place to promote environmentally sound practices, for example the "Green Globe" programme which independently rates tourist destinations by certain environmental criteria, and the International Hotels Environment Initiative. The Commission urged the tourism industry to continue these voluntary efforts and to work towards integrating them with government tourism development planning. During the talks, the World Travel and Tourism Council announced a new initiative to integrate tourism into local planning by linking its "Agenda 21 for the Travel and Tourism Industry" with the Local Agenda 21 programme used by over 1800 mayors and community leaders world-wide. Both programmes are based on Agenda 21, the global blueprint for sustainable development adopted at the Rio Earth Summit.

For more information, contact: UNEP Division of Technology, Industry and Economics, Tourism Programme, 39-43, quai André Citroen, 75739 Paris Cedex 15, France. Tel: +33 (1) 44 37 14 50, Fax: +33 (1) 44 37 14 74, E-mail: unep.tie@unep.fr, Internet: www.unepie.org. ◆

Books & Reports

GENERAL

Environmental Reports, Environmental Statements: Guidelines on Preparation and Dissemination

This guidebook for corporate environmental reporting begins with a discussion of the purpose and potential benefits of environmental reporting, as well as the cost and time involved. The authors consider effective ways to communicate with various target readers, including customers, neighbours and competitors. They outline what kinds of information should be included in a report and provide a sample structure. The book includes checklists to assess thoroughness and accuracy, and a discussion of requirements for companies that prepare environmental statements as part of their participation in the European Union's Eco-Management and Audit Scheme (EMAS). It was prepared by the International Network for Environmental Management, a non-profit federation of business organizations and cleaner production centres. Also available in German.

Jens Clausen and Klaus Fichter (1998). Future e.V., c/o Akzente, Rumfordstrasse 10, 80468 Munich, Germany. Tel: +49 (89) 290840-22/23, Fax: +49 (89) 290840-50, E-mail: future@unis.de, Internet: www.unis.de/future. Pbk, 58p.

Corporate Environmental Reports: A Guide for Environmental Managers

The Centre for Sustainable Design worked with a number of UK and international companies to produce this guidebook for environmental managers. It is intended to lead managers through the process of preparing an environmental report, dealing with both company information and personnel and outside suppliers. The authors stress the need for environmental communications to be integrated into corporate structures, and to be viewed as a source of competitive advantage rather than merely a response to legal requirements.

(1998). Centre for Sustainable Design, Surrey Institute of Art & Design, Falkner Road, Farnham, Surrey GU9 7DS, UK. Tel: +44 (1252) 892772, Fax: +44 (1252) 892747, E-mail: mcharter@surart.ac.uk, Internet: www.cfsd.org.uk. Pbk, 59p.

Electronic Environmental Reporting: Practical Checklists

This pamphlet addresses specific considerations in preparing electronic versions of corporate environmental reports. Published in the form of a series of checklists focusing on strategic issues, target audiences, format, and use of the Internet, it is aimed at companies that already conduct corporate environmental reporting.

Martin Charter (1998). Centre for Sustainable Design (see above). Pbk, 11p.

The Price of Pollution

Unlike material goods or services, the "environment" is not directly traded or marketed, making it difficult for industries and consumers to include environmental considerations in everyday economic decisions. The idea of using market forces to control environmental degradation has become increasingly popular in recent years, but the success of any efforts to do so will depend on setting prices on pollution. This study by the Centre for Energy Conservation and Environmental Technology (CE) in the Netherlands aims to create a basis for pollution pricing by calculating "shadow prices" for a number of key pollutants. Shadow prices are established by estimating limits to the amount of pollution society is willing to accept, and the amount of money it is willing to pay for the control methods necessary to restrict pollution to those limits. The authors have used Dutch environmental policy targets in their calculations, but they also apply their methods to other regions. Also available in Dutch.

Arie N. Bleijenberg, Marc D. Davidson and Ron Wit (1998). CE, Oude Delft 180, 2611 HH Delft, the Netherlands. Tel: +31 (15) 2 150 150, Fax: +31 (15) 2 150 151, E-mail: ce@antenna.nl, Internet: www.antenna.nl/ce. Pbk, 19p.

Ecological Impact Assessment

Ecological impact assessment predicts and analyses the impacts of development on ecosystems and their components. It is an important part of the more familiar environmental impact assessment process, but the author also describes other potential applications in the areas of environmental planning and management. *Ecological Impact Assessment* provides an overview of ecosystems analysis, with detailed chapters on performing the assessment process, as well as a discussion of ecological theories and tools that can be used to evaluate the ecological impacts of proposed development projects. It is intended for environmental consultants, regulators, scientists and developers directly involved in the ecological assessment process, as well as graduate and undergraduate students in this growing field.

Joanna Tetwell (1999). Blackwell Science Ltd., Osney Mead, Oxford OX2 0EL, UK. Distributed by Marston Book Services, Ltd., PO Box 269, Abingdon, Oxon OX14 4YN, UK. Tel: +44 (1235) 465 500, Fax: +44 (1235) 465 555, Pbk, 351p, ISBN 0-632-03738-5.

Green Building Advisor

This interactive CD-ROM helps assess the environmental impacts of a building project and identify ways to reduce them. It allows users to enter information about a project, and then recommends appropriate design strategies in response. Strategies are arranged in five environmental impact categories – site and ecosystems, energy use, water use, resources and materials, and indoor environment. The recommendations give a range of initial and lifetime costs for each strategy, and the programme can be instructed to limit its responses according to budgetary or design constraints. The CD-ROM also includes case studies of new construction and renovation projects, and searchable reference libraries with listings of 1300 green building materials. The software is intended for practitioners and students of architecture, design and planning, as well as their clients. It was produced by the Center for Renewable Energy and Sustainable Technology. E Build (publishers of *Environmental Building News*) and Design Harmony, an architectural and environmental consulting firm.

(1999). CREST Software, 1612 K Street, NW, Suite 410, Washington, DC 20006, USA. Tel: +1 (510) 588-1112, Fax: +1 (202) 293-5857, E-mail: gba@crest.org, Internet orders: www.sbtacrest.org/software-central/html/gba.html.

Ecospace Audit

The concept of environmental space or ecospace is based on the idea of "fair shares in environmental space", which aims to determine a sustainable resource use per person taking global and individual welfare into account. The concept has been promoted by Friends of the Earth Europe through its Sustainable Europe Campaign. As part of their effort to translate environmental space ideas into concrete, measurable and specific steps that companies can take towards sustainability, Friends of the Earth and affiliated environmental organizations, academics and corporations developed an ecospace audit that producers can use to assess the environmental and social impacts of their resource use. The audit focuses on the amount of resources that enter a product or service during its entire life-cycle, from resource extraction through processing to consumption and waste disposal. It also takes into account labour conditions, respect for human rights, and local environmental, health and political conditions that companies must consider when attempting to turn their production in a more sustainable direction.

M. Buitenkamp and P. Spagnoli (1999). Milieudefensie, Plantage Middenlaan 2c, Postbus 18169, 1001 ZB Amsterdam, the Netherlands. Tel: +31 (20) 624 9389, Fax: +31 (20) 625 5203, E-mail: info@milieudefensie.nl, Internet: www.milieudefensie.nl. Pbk, 43p.

Product design and environment – 90 examples of eco-design/ Conception de produits et environnement – 90 exemples d'éco-conception

This publication illustrates the concept of eco-design through 90 examples of products designed with environmental considerations in mind. Ranging from pesticides to photocopiers, they were developed using a variety of environmental strategies such as recycled or recyclable materials, energy-saving technology, or logistical and material optimization during production. The survey of eco-design follows four main threads: product life-cycle analysis, consumer information and appeal, co-operation and information-sharing in product design, and medium and long-term strategic challenges. It was produced by the French Agency for Environment and Energy Management (ADEME), and the complete text is given in both English and French.

(1999). ADEME, 27, rue Louis Vicat, 75737 Paris Cedex 15, France. Tel: +33 (1) 47 65 20 00, Fax: +33 (1) 46 45 52 36, Internet: www.ademe.fr, Pbk, 107p, ISBN 2-86817-398-5.

Environmental Statistics: Analysing Data for Environmental Policy

Environmental statistics are important for assessing environmental effects and conditions and formulating environmental policies. The papers collected here were contributed by professional, academic and government statisticians on a variety of statistical issues related to the environment. Topics include specialized statistical techniques for analysing environmental data, mathematical models, and the problems of coordinating data from a wide geographical area or from many different areas of measurement. Included is a discussion of environmental policy issues affected by the nature and quality of statistical information.

(1999). John Wiley & Sons, Baffins Lane, Chichester, West Sussex PO19 1UD, UK. Tel: +44 (1243) 779 777, Fax: +44 (1243) 775 878, E-mail: cs-books@wiley.co.uk, Internet: www.wiley.com, Hbk., 283p, ISBN 0-471-98540-6.

Environmental Cost Internalization: Case Studies from the Czech Republic, Egypt and South Africa

Internalization of environmental costs is often proposed as a strategy for reducing environmental degradation. This strategy is based on the theory that users of environmental resources typically do not pay the full cost of using them, and are therefore encouraged to use or degrade more natural resources than would be the case if they had to pay for them at full value. However, internalizing costs is complicated and can be difficult to implement, in part because there is no standard system for assigning value to environmental resources that may be intangible, such as clean air or ecosystems diversity. One of the greatest difficulties is identifying and measuring a society's priorities in making choices or trade-offs among various aspects of development and environmental preservation. To address these problems, UNEP funded a study carried out jointly with the UN Conference on Trade and Development (UNCTAD) in the Czech Republic, Egypt and South Africa. Its purpose was to identify major environmental problems and the externalized environmental costs of trade and production-related activities, to propose policies and measures these countries could use to internalize costs, and to identify obstacles to implementation of such policies. Each study identifies local structural, economic and political conditions that currently inhibit full internalization of costs and makes recommendations for overcoming these barriers.

(1999). UNCTAD, Palais des Nations, CH-1211 Geneva 10, Switzerland. Tel: +41 (22) 917 26 12/26 06/26 13, Fax: +41 (22) 917 00 27, E-mail: unpubli@unog.ch, Pbk, 102p.

Accounting and Financial Reporting for Environmental Cost Liabilities

Environmental accounting, which evaluates an enterprise's environmental performance and costs, has become an increasingly important business tool. However, its practical implementation has been slowed by the lack of recognized, nationally mandated and broadly applicable accounting standards that could accurately count environmental costs. UNCTAD's Intergovernmental Working Group of Experts on International Standards of Accounting and Reporting (ISAR) has developed guidelines for environmental reporting and monitored their impact on corporations' annual statements. The group found that there is widespread reluctance on the part of companies to voluntarily disclose environmental information, partly because they are waiting for government direction on standards and requirements. Working with the World Bank, the group has now revised and expanded its position paper in response to the need for more structured guidance. The book includes the full text in Arabic, Chinese, English, French, Russian and Spanish.

(1999). UNCTAD (see above). Pbk, 177p, ISBN 92-1-012041-8.

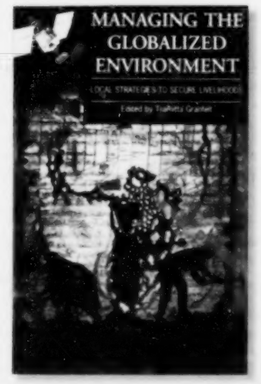
International Accounting and Reporting Issues: 1998 Review

ISAR's 15th session in February 1998 was devoted to recent developments in environmental accounting, especially environmental financial accounting and reporting at the corporate level. This volume includes the position paper, also published as a separate volume (see above), as well as background papers and summaries of expert discussions of the issues at the ISAR session. It reviews current national guidance on accounting for environmental costs and liabilities, identifies key environmental performance indicators, and examines their relationship to financial performance. Best practices for measuring and communicating environmental performance are reviewed, and recommendations are made for improving the indicators used to report environmental performance in a coherent and useful way.

(1999). UNCTAD (see above). Pbk, 203p, ISBN 92-1-112444-1.

Managing the Globalized Environment

Subtitled "Local Strategies to Secure Livelihoods," *Managing the Globalized Environment* focuses on the impacts of local value systems, entitlement patterns, governance and other socio-cultural factors in resource management. Because different perceptions and priorities exist in different socio-cultural systems, the authors argue that environmental management tools and systems should take local traditions and cultural factors into account. They support the idea that potential for



conflict arises not only from control of resources, but also from varied ways of thinking about the natural resource base, its ownership and its proper use.

T. Granfelt, ed. (1999). Intermediate Technology Publications, 103-105 Southampton Row, London WC1B 4HH, UK. Tel: +44 (171) 436 9761, Fax: +44 (171) 436 2013, E-mail: orders@itpub.org.uk, Internet: www.oneworld.org/itdg/publications. Pbk, 192p. ISBN 1-85339-453-3.

Statistical Aspects of Health and the Environment

This volume of proceedings of the SPRUCE Conference, held in the Netherlands in September 1997, is the fourth in a series concerning statistics and the environment. It includes papers on current methods and the development of research trends in the study of statistical aspects of health and the environment. The contributing authors cover statistical analysis of a variety of research areas, such as the spread of malaria and the effects of air pollution on asthma, as well as technical aspects of statistical data collection and modelling of health and environment-related problems.

V. Barnett, A. Stein and K.F. Turkman, eds. (1998). John Wiley & Sons, Baffins Lane, Chichester, West Sussex PO19 1UD, UK. Tel: +44 (1243) 779 777, Fax: +44 (1243) 775 878, E-mail: cs-books@wiley.co.uk, Internet: www.wiley.com. Hbk., 404p. ISBN 0-471-97645-8.

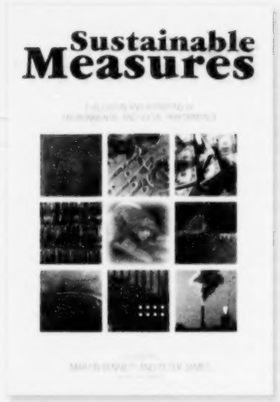
A Case for Wetland Restoration

Reviewing 20 years of wetland restoration efforts, the authors of *A Case for Wetland Restoration*, both of whom are active in this field, seek to answer the question of whether such interventions can be successful in the long term. They examine four restoration efforts at sites in the United States with different local ecological characteristics, histories and problems. While acknowledging that wetland restoration is a much criticized and fairly new endeavour, they claim that these and other projects have been largely successful and provide lessons on the potential – and potential problems – of wetland restoration in general. In addition to these case studies, the book examines planning and design considerations, legal and regulatory requirements, public involvement and technical issues.

D.L. Hey and N.S. Philippi (1999). John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012, USA. Tel: +1 (212) 850-6011, Fax: +1 (212) 850-6008, E-mail: info@wiley.com, Internet: www.wiley.com. Hbk., 215p. ISBN 0-471-17642-7.

Sustainable Measures

Businesses increasingly use environmental and social reporting to assess and convey information on their environmental performance. There is consequently a greater need for standardized measurement and evaluation procedures. A number of standardization efforts and proposals exist.



UNEP, for example, sponsors and participates in the Global Reporting Initiative (GRI). *Sustainable Measures* surveys the current state of environmental reporting standards, including the GRI. Contributors from business, NGOs and academia examine reporting practices in several countries around the world and present case studies on a range of companies. Issues covered include report standardization and comparability, sustainability measures, best practices, and the special concerns of developing countries.

M. Bennett and P. James, eds. (1999). Greenleaf Publishing, Aizlewood Business Centre, Aizlewood's Mill, Nursery Street, Sheffield S3 8GG, UK. Tel: +44 (114) 282 3475, Fax: +44 (114) 282 3476, E-mail: greenleaf@worldscope.co.uk, Internet: www.greenleaf-publishing.com. Hbk., 386p. ISBN 1-874719-16-0.

Fifth International Conference on Environmental Compliance and Enforcement

The International Network for Environmental Compliance and Enforcement (INECE), a joint effort of UNEP, national environmental ministries, NGOs and the World Bank, sponsored this conference in Monterey, California, in November 1998. INECE's goals are to develop a common framework and principles for enforcement of national and international environmental laws, and to understand and use driving forces in this area while overcoming barriers to effective enforcement. It holds a biennial conference to review progress and strengthen cooperation in international environmental law enforcement. The first volume of the conference proceedings is a compilation of the papers presented; the second volume includes speeches, summary reports of conference sessions and workshops, and additional papers.

The text of the proceedings of this and the previous conferences is also available on the Internet at www.inece.org/initconf.htm.

(1999). INECE, c/o Cheryl Wasserman, US EPA, Office of Enforcement and Compliance Assurance, 401 M Street, SW, MC 2251A, Washington, DC 20460, USA. Tel: +1 (202) 564-7129, Fax: +1 (202) 564-0070, E-mail: wasserman.cheryl@epa.gov, Internet: www.inece.org. Pbk, 2 vols, 724p. and 648p.

ENERGY

Reforming the Power Sector in Africa

The power sector in many African countries has traditionally been characterized by state ownership and a public sector monopoly. A number of countries are moving away from this model, which has often been criticized for inefficiency, waste and corruption. Many power suppliers are unable to provide adequate service to rural and poor areas. Their environmental, technical and financial performance is also unsatisfactory. Reforming the power sector is an important part of the transition to both a market-based economy and sustainable development. This book examines the process of restructuring and reform in the power sector in four countries in Sub-Saharan Africa: Malawi, Tanzania, Uganda and Zimbabwe. The case studies illustrate the diversity of reform needs and actions in Africa. The authors include recommendations for policy options and other actions in the areas of performance and efficiency, decentralization of power generation and distribution functions, and the legal and regulatory framework.

M.R. Bhagavan, ed. (1999). Zed Books Ltd., 7 Cynthia Street, London N1 9JF, UK. Tel: +44 (171) 837 4014, Fax: +44 (171) 833 3960, E-mail: zedbooks@zedbooks.demon.co.uk, Internet: www.zedbooks.demon.co.uk. Hbk., 380p. ISBN 1-85649-667-8.

CLIMATE CHANGE/ AIR POLLUTION

USEA/USAID Handbook of Climate Change Mitigation Options for Developing Country Utilities and Regulatory Agencies

This handbook, prepared for the US Energy Association and the US Agency for International Development, reviews the "best practices" available for electric power generation, transmission, distribution and consumption in developing countries. It emphasizes their climate change implications, as well as discussing the technical and financial means available to implement them. Covered are climate change and pollution control, fuel systems, conventional power generation, transmission and distribution systems, end-use efficiency, renewable energy sources, emission trading, and institutional and regulatory reform. Also discussed are market-based instruments that could be used to encourage adoption of best practices.

(1999). United States Energy Association, 1300 Pennsylvania Avenue, NW, Suite 550, Mailbox 142, Washington, DC 20004-3022, USA. Tel: +1 (202) 312-1230, Fax: +1 (202) 682-1682.

Beyond Buenos Aires

The OECD and the International Energy Agency (IEA) sponsored the 1999 Forum on Climate Change, "Beyond Buenos Aires", held in Paris in March. This document presents a summary of the meeting, which focused on the results of the Fourth Conference of the Parties to the UN Framework Convention on Climate Change (COP4) in Buenos Aires in November 1998 and the Buenos Aires Action Plan. Topics covered include the Clean Development Mechanism, international emissions trading, government policies and priorities for meeting the Action Plan requirements (especially in developing countries), and the role of OECD and IEA in undertaking some of the work related to the Action Plan. The document, which includes a contact list of participants, is available at www.oecd.org/env/cc.

(1999). OECD Environment Directorate, 2, rue André-Pascal, 75775 Paris Cedex 16, France. Tel: +33 (1) 45 24 82 00, Fax: +33 (1) 44 30 63 99, E-mail: jan.corfee-morlot@oecd.org, Pbk, 27p.

CHEMICALS, POLLUTION AND ACCIDENTS

Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface

Many polluting substances diminish naturally over time in water, soil and groundwater through chemical changes, dilution, dispersion and other processes. These natural processes, also called "passive remediation", are often used to control water quality in surface water bodies that receive industrial or municipal waste discharges. Water quality models are routinely used to calculate the capacity of such water bodies to absorb pollutants. Natural attenuation can also be effective in reducing contamination from a spill or other source in soil and groundwater, but the chemical and physical processes involved are less well understood than in the case of surface water.

This textbook surveys both biotic and abiotic natural attenuation processes in soil and groundwater. Fuels and chlorinated solvents are among the most common groundwater pollutants. The authors, who describe techniques for accelerating natural attenuation processes and modelling their effectiveness, present case studies and examples from a variety of situations. The book also includes sections on monitoring and evaluation [illegible] processes. It is intended for scientists, engineers, regulators and consultants in the field of environmental remediation, as well as students and professors in environmental engineering and related disciplines.

J.H. Wiedemeyer, H.S. Rifai, C.J. Newell and J.T. Wilson (1999). John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012, USA. Tel: +1 (212) 850-6011, Fax: +1 (212) 850-6008, E-mail: info@wiley.com, Internet: www.wiley.com. Hbk., 617p. ISBN 0-471-19749-1.

S-Centred Radicals

Sulphur-containing radicals, formed from emissions generated by natural sources such as volcanoes as well as from power plants and vehicle emissions, play important roles in the atmosphere and in living organisms. This textbook presents a review of recent research and developments in the field of S-centred radical chemistry. It is intended for researchers and students in organic and environmental chemistry.

Z.B. Alfassi, ed. (1999). John Wiley & Sons, Baffins Lane, Chichester, West Sussex PO19 1UD, UK. Tel: +44 (1243) 779 777, Fax: +44 (1243) 775 878, E-mail: cs-books@wiley.co.uk, Hbk., 377p. ISBN 0-471-98657-9.

Practical Guide for Marine Chemical Spills

This handbook is intended to help choose appropriate responses to an actual or threatened marine spill of hazardous materials. The response options are presented in the form of decision trees, using the information available to guide the user through a variety of incident scenarios. Recommended responses are based on the International Maritime Organization's behaviour classification system for chemicals spilled at sea. Also included is information on the behaviour and compatibility of commonly transported chemicals, the chemical resistance of various materials and equipment, and safety precautions when entering spill sites.

(1999). Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), Manoel Island, GZR 03, Malta. Tel: +356 33 72 96, Fax: +356 33 99 51, Pbk, 103p.

Proceedings of the OECD International Conference on Pollutant Release and Transfer Registers (PRTRs)

PRTRs contain information – provided by governments or industry – on the amounts of pollutants released or transferred off-site for disposal, their potential risks and their locations. The availability and completeness of such information can determine the effectiveness of governments' environmental policies and emergency response plans. The OECD sponsored this conference in Tokyo in September 1998 to discuss developments in PRTR implementation, including lessons learned from efforts to develop PRTRs and the challenges and obstacles being faced. The proceedings contain presentations and case studies on PRTR programmes in several countries, as well as discussions of technical and policy issues. They are available at www.oecd.org/ehs.

(1999). OECD Environment Directorate, Environmental Health and Safety Division, 2, rue André-Pascal, 75775 Paris, France, Fax: +33 (1) 45 24 16 75, E-mail: ehsunit@oecd.org, 2 vols, 446p.

Quantitative Microbial Risk Assessment

Exposure to microbial contamination through food, water supplies, soil or animals causes serious disease or death to millions of people each year. Control of microbial pathogens, and an understanding of the risks they pose, are therefore essential for public health officials and for water and sanitary utility operators. This guide to the quantitative risk assessment of infectious agents covers their characteristics and modes of transmission, as well as techniques of risk, hazard and exposure assessment. Chapters cover hazard identification, analytical methods, exposure and dose-response assessment and risk characterization. Included are case studies and worked examples of risk assessment problems.

C.N. Haas, J.B. Rose and C.P. Gerba (1999). John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012, USA. Tel: +1 (212) 850-6011, Fax: +1 (212) 850-6008, E-mail: info@wiley.com, Internet: www.wiley.com. Hbk., 449p. ISBN 0-471-28357-8.

INDUSTRY SECTORS

Costs and Strategies Presented by Industry during the Negotiation of Environmental Regulations

This study was sponsored by the Swedish Ministry of Environment to examine the costs of environmental compliance as experienced by affected industries. Industry often perceives regulations as undue constraints on profitability and competitiveness, but it has sometimes been accused of exaggerating their impact. The study looked at the arguments and strategies presented by American and European industry representatives during negotiations on national, regional and international environmental regulations. The authors used five different regulations as case studies to assess how industry's estimated compliance costs, as presented during negotiations, compared with actual costs incurred in implementing regulatory requirements. They point out that "industry" is not a monolithic entity with a single set of business goals, but a vast range of complex and often opposing interests. While careful not to draw overly broad conclusions, they find that business costs are often overestimated while companies' ability to respond to new requirements with innovative technologies is often underestimated.

(1999). Stockholm Environmental Institute, Box 2142, S-103 14 Stockholm, Sweden, Tel: +46 (8) 412 1400, Fax: +46 (8) 723 0348, E-mail: postmaster@sei.se, Internet: www.sei.se, Pbk, 64p.

WATER

Wastewater Microbiology

Wastewater Microbiology provides basic background information on the microbiology, metabolism and ecology of wastewater. It surveys microbiological developments and public health aspects of wastewater treatment. Chapters discuss practical issues in regard to treatment, disinfection, pollution control and remediation, as well as new technologies for detecting pathogens and parasites and the emergence of newly identified pathogens. This book is intended for administrators and engineers in the field of microbiology, public health officials and environmental engineering students.

G. Bitton (1999). John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012, USA. Tel: +1 (212) 850-6011. Fax: +1 (212) 850-6088. E-mail: info@wiley.com. Internet: www.wiley.com. Hbk., 578p. ISBN 0-471-32047-1.

The Price of Water: Trends in OECD Countries

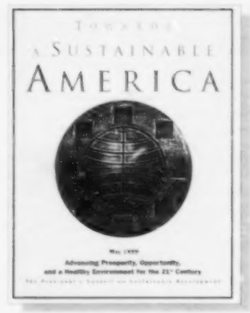
Water pricing practices are important in regard to the economic efficiency of water services and their environmental impacts. The OECD, which predicts that water supply problems will be a major constraint on sustainable development in the 21st century, considers water pricing to be a key tool to address this problem. *The Price of Water* presents an overview of water price practices and trends in the household, agricultural and industrial sectors in OECD countries. It covers price issues concerning public water supplies, sewage treatment and disposal, water abstraction and discharge fees, and cost recovery. Noting that there is a trend away from government-run water utilities and towards increasing private-sector involvement, it discusses economic factors such as supply responsiveness to price changes, the effect of subsidies and policy changes, and the environmental effects of water use. It is also available in French.

(1999). OECD Publications, 2, rue André-Pascal, 75775 Paris Cedex 16, France. Tel: +33 (1) 45 24 82 00. Fax: +33 (1) 49 10 42 76. E-mail: compte.pubinq@oecd.org. Internet: www.oecd.org. Pbk., 17p. ISBN 92-64-17079-0.

NATIONAL/REGIONAL

Towards a Sustainable America

The President's Council on Sustainable Development (PCSD) was created to advise the US President on ways to integrate environmental, economic and social goals. Over a period of six years the Council held a series of public meetings and workshops, consulted experts and community groups, and worked with business leaders to develop recommendations on a wide range of environmental and sustainability issues. This volume contains the PCSD's third and final report, which presents strategies for reducing greenhouse gas emissions, promoting corporate environmental management, improving urban and rural land use practices, and pursuing simultaneous economic growth, environmental protection and social justice. It includes practical proposals and "success stories" as well as recommendations for nation.l policy. The full report, and the two preceding reports, can be ordered on-line.



(1999). US Government Printing Office, Superintendent of Documents, PO Box 371954, Pittsburgh, PA 15250-7954, USA. Tel: +1 (202) 512-1800. Fax: +1 (202) 512-2250. E-mail: gpoaccess@gpo.gov. Internet: www.access.gpo.gov/su_docs/sale.html. Pbk, 158p.

Material Evidence: Practical Recommendations for National and European Resource Use

This report is the product of the Sustainable Use of Resources in Europe (SURE) project, which carried out research on resource use across Europe. The aim was to identify opportunities to improve resource management and reduce waste generation, in keeping with the SURE project's broader goals of campaigning for effective resource management and raising public awareness of the effects of present levels of resource consumption. The report compiles country reports by local Friends of the Earth organizations in the United Kingdom, Italy, the former Yugoslav Republic of Macedonia, the Netherlands, Scotland, Spain and the Ukraine. In each country researchers used national data on per capita resource consumption, production and waste generation to analyse and draw conclusions about the sustainability implications of current consumption trends. The report identifies barriers to sustainable resource use and makes recommendations for reducing the impacts of consumption through changes in government policy, data collection and monitoring, and the establishment of national and EU targets for reduction of resource use.

(1999). Friends of the Earth Scotland, 72 Newhaven Road, Edinburgh EH6 5QG, Scotland, UK. Tel: +44 (131) 554 9977. Fax: +44 (131) 554 8656. E-mail: sure@foe-scotland.org.uk. Internet: www.foe-scotland.org.uk. Pbk, 247p. ISBN 1 901855-07-4.

Environment for Europe

The Fourth Pan-European Conference of Environmental Ministers held in Aarhus, Denmark, in June 1998 was a significant step towards integration of environmental action in eastern, central, and western Europe. Thirty-five ministers and the European Commission signed the Convention on Access to Information, Public Participation in Environmental Decision-Making and Access to Justice in Environmental Matters, better known as the Aarhus Convention. The Conference also considered a range of issues including the environmental problems of economies in transition, air pollution, business and the environment, energy, biological diversity, and the phase-out of lead in vehicle fuels.

The proceedings contain all the political statements and keynote addresses made during the Conference, including the Ministerial Declaration, and summaries of Conference sessions on individual topics and issues. They also include contact information for participants. They are available free of charge through the Danish Environmental Protection Agency. Additional information on the Conference is available in English and Danish on the Ministry's web site at www.mem.dk/aarhus-conference.

(1999). Ministry of Environment and Energy, Danish Environmental Protection Agency, Strandgade 29, DK-1401 Copenhagen K, Denmark. Tel: +45 3266 0100. Fax: +45 3266 0479. Internet: www.mst.dk. Pbk, 352p. ISBN 87-7909-373-6.

Convention on Access to Information, Public Participation in Environmental Decision-Making and Access to Justice in Environmental Matters

This publication presents the full text of the Aarhus Convention in the six official UN languages (Arabic, Chinese, English, French, Russian and Spanish).

(1999). UN Publications, Sales Office and Bookshop, CH-1211, Geneva 10, Switzerland. Tel: +41 (22) 917-2614. Fax: +41 (22) 917-0027. E-mail: unpubli@unog.ch. Internet: www.un.org/pubs. Pbk, 71p. ISBN 92-1-016337-90.

Environmental Protection: Review of European Legislation up to January 1, 1999

This reference guide contains a list and brief summary of all environment-related European Commission proposals and measures adopted by the EU Council of Ministers. It includes the date of publication or adoption of each measure and reference information for the full texts. The list is arranged by environmental policy sector, with references to water, air, chemicals, noise, waste, land and nature, flora and fauna, nuclear safety and other subjects.

Web Site Highlight

HORIZONS
www.solutions-site.org/default.htm

The HORIZONS Solutions Site seeks to provide readily accessible answers to problems concerning environment, health, population and development. It presents case studies and new initiatives on successful approaches and technologies. The case studies, which have been academically reviewed, are related to energy, water, waste management, transportation, toxic chemicals, public health, population, industry, desertification, biodiversity, air pollution and agriculture. The interactive site is a collaboration among HORIZON Communications, UNEP and other UN bodies, Harvard and Yale Universities, and Canada's International Development Research Centre.

For more information, contact: Ms. Jo Vellis, Vice President, HORIZON Communications, Yale University Department of Biology, PO Box 208103, New Haven, CT 06520-8103, USA. Tel: +1 (203) 432-6266. Fax: +1 (203) 432-6161. E-mail: vellis@pantheon.yale.edu.

Mineral Resources Forum
www.natural-resources.org/environment

Operated in collaboration with UNCTAD, UNEP's Mineral Resources Forum permits anyone with Internet access to obtain and supply information on mining and the environment. It is interactive, allowing users to contribute their own material as well as to obtain documents and up-to-date information online. The site contains the following components:

- an overview of environmental issues related to mining, with a guide to finding online information about them;
- news items concerning mining and the environment. Users may send in their news, which is immediately added to the site, while the system manager puts significant news items on the home page;
- conferences on mining and the environment, contributed by users;
- publications, briefing papers and documents, some of which may be downloaded or accessed online;
- a "questions and answers" page, where users may pose questions or answer those of other users;
- a comprehensive list of related sites, including information about each site; and
- a business directory, to which users may add details of their services.

For more information, contact: Fritz Balkau, UNEP TIE, Paris. Tel: +33 (1) 44 37 14 50. Fax: +33 (1) 44 37 14 74. E-mail: fritz.balkau@unep.fr.

Wuppertal Institute
www.wupperinst.org/Sites/home1.html

The Wuppertal Institute for Climate, Environment and Energy performs research in the areas of climate change policy, resource flows, energy and transport with the goal of working towards sustainable culture and technology. The Institute has developed innovative methods for material flow analysis that can be used to develop sustainable material flow cycles and eco-efficient production of goods and services. Its web site provides access to publications, employment and internship information, as well as links to other sustainability-related academic and institutional sites. Many of its publications can be downloaded from this site. The German-language site, at www.wupperinst.org/Seiten/home1.html, provides more information on the Wuppertal Institute's programmes and publications.

For more information, contact: Wuppertal Institute, PO Box 10 04 80, 42204 Wuppertal, Germany. Tel: +49 (202) 2492-0. Fax: +49 (202) 2492-108. E-mail: info@wupperinst.org.

National Pollutant Release Inventory (Canada)
www.ec.qc.ca/pdb.npri

The Government of Canada has made its database on air, water and land pollution release sites and hazardous substance transfer and handling information available to the public. Under the recently expanded National Pollutant Release Inventory (NPRI) programme, companies operating in Canada are required to report information on their handling and release of 246 chemicals. The NPRI is available as a searchable online database; users can type in a postal code or telephone area code to locate nearby pollution release sites.

For more information, contact: NPRI Office, Environment Canada, 9th floor, Place Vincent Massey, 351 St. Joseph Blvd., Hull, QC, K1A 0H3, Canada. Tel: +1 (819) 953-1656. Fax: +1 (819) 994-3266. E-mail: NPRImail@ec.gc.ca.

A. Eckstein (1999). Europe Information Service, 66 avenue Ad. Lacomblé, B-1030 Brussels, Belgium. Tel: +32 (2) 737 7709. Fax: +32 (2) 732 6757. E-mail: eis@eis.be. Internet: www.eis.be. Pbk, 95p.

Environmental Performance Review: Turkey

The OECD's Environmental Performance Review series presents environmental and economic data on OECD and a few non-OECD countries. Each study includes information on the subject country's geography and resources, a survey of its social, economic and institutional development, and an analysis of its environmental policies. There are assessments of current environmental conditions and of air, water and waste management programmes. The country's integration of environmental and economic decisions is examined, along with its progress in meeting both domestic objectives and international commitments. Recommendations are made concerning overall policy implementation and selected industry sectors. The OECD review of Turkey has just been published. Environmental Performance Reviews have also been carried out on Australia, Austria, Belarus, Belgium, Bulgaria, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Russian Federation, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The studies of Belarus, Bulgaria, Estonia and Slovenia were carried out in cooperation with the UN Economic Commission for Europe (UN/ECE).

(1999). OECD Publications, 2, rue André-Pascal, 75775 Paris Cedex 16, France. Tel: +33 (1) 45 24 82 00. Fax: +33 (1) 49 10 42 76. E-mail: compte.pubinq@oecd.org. Internet: www.oecd.org. Pbk, 186p. ISBN 92-64-17106-1.

Technology Needs for Lake Management in Indonesia

Raw Dana and Raw Penning, two small lakes on the island of Java, are important to local ecology and economic activity. Both are highly degraded and continue to be threatened by poor management and environmentally unsound practices. UNEP's International Environmental Technology Centre collaborated with the Government of Indonesia in carrying out studies of the two lakes and making recommendations on water management and technical issues that need to be addressed to achieve ecological sustainability. The study also includes findings and recommendations that are more broadly applicable to the problems of lake management in Indonesia.

(1999). UNEP IETC, Osaka Office: 2-110 Ryokuchi Koen, Tsurumi-ku, Osaka 538-0036, Japan. Tel: +81 (6) 6915-4580. Fax: +81 (6) 6915-0304. Shiga Office: 1091 Oroshimo-cho,

Kusatsu City, Shiga 525-8001, Japan. Tel: +81 (77) 568-4586. Fax: +81 (77) 568-4587. E-mail: tetc@unep.or.jp. Internet: www.unep.or.jp. Pbk. 152p. ISBN 92-807-1510-0.

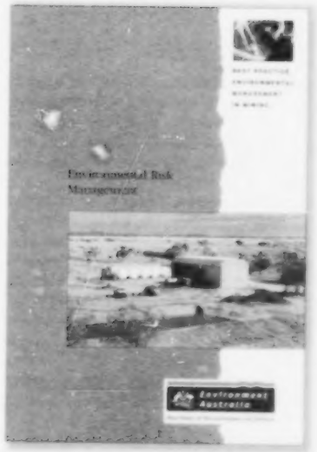
Implementing ISO 14000 Standards in Asia and the Pacific

The ISO 14000 international standards for environmental practices are a widely used corporate environmental management tool. However, many companies have been reluctant to undertake the ISO 14000 certification effort because of concerns about cost, the technical ability required, and the availability of institutional support and incentives. These concerns are particularly relevant to small and medium-sized enterprises. The Asian Productivity Organization (APO) has published this guide to ISO 14000 issues in Asia and the Pacific with the aim of addressing implementation issues. It includes the report of a 1997 APO workshop. Participants noted the difficulties posed by lack of standardized accrediting procedures and variations in the credibility of auditing and certifying bodies. Although the costs of implementation are a major concern, many companies have found that cleaner production methods, improved housekeeping and other initiatives reduce consumption of resources and operating costs. Trade and policy implications of ISO 14000 standards are discussed, as well as financial and other incentives and assistance for companies that wish to implement these standards.

1998. APO, Hirakawacho Daiichi Seimei Building 2F, 2-3-10 Hirakawacho 1-chome, Chiyoda-ku, Tokyo 102-0093, Japan. Tel: +81 (3) 5226 3930. Fax: +81 (3) 5226 3950. E-mail: apo@gol.com. Internet: www.apo-tokyo.org. Pbk. 142p. ISBN 92-833-2334-6.

Best Practice Environmental Management in Mining

This series of booklets published by Environment Australia is intended to help all sectors of the mining and extraction industries – minerals, coal, oil and gas – protect the environment and reduce the impacts of production processes. They include examples of current best practice in environmental management in mining. Basic principles, guidance and advice are presented, along with case studies from leading Australian companies and



reference checklists.

There are plans to produce 27 booklets. So far, 17 have been published in English; the first nine are also available in Indonesian, Mandarin and Spanish. An introductory video is available in all four languages.

Office of the Supervising Scientist, Environment Australia, PO Box E305, Kinnaba ACT 2604, Australia. Tel: +61 (2) 6217 2010. Fax: +61 (2) 6217 2060. E-mail: ssg@ea.gov.au. Internet: www.environment.gov.au/epg/supervising/booklets.html.

DIRECTORIES

European Centres of Expertise in Water and Wastewater Treatment

This CD-ROM provides details on over 500 companies, consultants and institutes throughout Europe that are active in water and wastewater treatment. It includes information on their activity areas, treatment technologies and applications, as well as an analysis of market trends and new developments. The database is intended to allow those in the water and wastewater treatment field to identify business, joint venture or collaboration opportunities, and to contact major research institutions and government agencies.

1999. Mayer Marnoch Ltd., Caledonian House, Hammersmith Grove, London W6 0HT, UK. Tel: +44 (208) 563 0666. Fax: +44 (208) 563 0040. E-mail: water@mayer-marnoch.com. Internet: www.mayer-marnoch.com/water.html. CD-ROM. ISBN 0-903231-83-0.

I recently had the "pleasure" of picking up a rather well presented GLOSSY *Industry and Environment* quarterly review entitled "Industrial Accidents: Prevention and Preparedness."

I would like to express a personal opinion. You are the United Nations ENVIRONMENTAL Programme – your logo being "For Life on Earth"? Yet while I was reading your review, the glossy paper kept glaring in my eyes. This e-mail is not about my eyes – it is about you, the foremost "authority" on environment using non-environmentally friendly methods to publish your reviews. What exactly are you trying to propagate – sustainability? the saving of our fragile environment for our children and grandchildren?

I cannot explain how upset I am that an organization like UNEP is not doing anything practical to show that it does actually stand For Life on Earth.

Please practise what you preach – or at least attempt to show the world that you do.

Fareena Chaudhry
Via e-mail

UNEP's response

The UNEP quarterly *Industry and Environment* is printed on 100% chlorine-free paper, including the glossy cover. We fully share our readers' concern for the environment. At UNEP we do use environmentally friendly practices. However, the choice between different types of "green" products is not always an easy one.

More and more printing paper contains a mix of recycled and virgin fibers. The printer with which UNEP contracts to produce *Industry and Environment* has not been able to tell us what the recycled fiber content of the paper we use is, but we will continue to seek this information concerning all the products we purchase.

Finally, please note that a number of life cycle assessments have found that fully recycled paper is not always the most environmentally friendly choice. For example, one study in Australia found that if the paper is transported more than about 20 kilometres by road, the energy balance is not in favour of recycling. In some countries paper produced from local agricultural wastes, such as rice straw, may be more environmentally friendly and cleaner than products made from imported chipped long-distance to be recycled.

We hope we have reassured your about UNEP's environmental conscience and that you will enjoy reading *Industry and Environment* in the future.

THE UNEP DIVISION OF TECHNOLOGY, INDUSTRY AND ECONOMICS

Current uses and development of natural resources, technologies and production processes, as well as urbanization patterns, have negative effects on human health and the environment. This is illustrated by unsustainable use of water, land and energy, air and water pollution, persistent and toxic bio-accumulative chemicals in the food chain, and other industry-related problems. To have a healthy environment, we need to change how we produce and consume goods and services. This change involves revising and developing economic policies and trade practices so as to integrate environmental issues in the planning and assessment processes.

UNEP's Division of Technology, Industry and Economics (UNEP TIE) was created in 1998 to help decision-makers in governments, local authorities and industry develop and adopt policies and practices that:

- are cleaner and safer;
- use natural resources efficiently;
- ensure adequate management of chemicals;
- incorporate environmental costs;
- reduce pollution and risks for humans and the environment.

UNEP TIE, whose main office is in Paris, is composed of:

- **The International Environmental Technology Centre (Osaka)**, which promotes the adoption and use of environmentally sound technologies, with a focus on the environmental management of cities and freshwater basins, in developing countries and countries in transition.
- **The Production and Consumption Unit (Paris)**, which fosters the development of cleaner and safer production and consumption patterns that lead to increased efficiency in the use of natural resources and reductions in pollution.
- **The Chemicals Unit (Geneva)**, which promotes sustainable development by catalyzing global actions and building national capacities for the sound management of chemicals and the improvement of chemical safety world-wide, with a priority on Persistent Organic Pollutants (POPs) and Prior Informed Consent (PIC, jointly with FAO).
- **The Energy and OzonAction Unit (Paris)**, which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition, and promotes good management practices and use of energy, with a focus on atmospheric impacts. The UNEP/RISØ Collaborating Centre on Energy and Environment supports the work of this Unit.
- **The Economics and Trade Unit (Geneva)**, which promotes the use and application of assessment and incentive tools for environmental policy, and helps improve the understanding of linkages between trade and environment and the role of financial institutions in promoting sustainable development.

UNEP
UNITED NATIONS ENVIRONMENT PROGRAMME
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http://www.uneptie.org/home.html

FEEDBACK

If you would like to respond to something you've read here – to agree or disagree with a point of view, clarify a fact, or provide additional information – write to us. If you would like to air your views on any other subject relevant to *Industry and Environment*, we would also like to hear from you. As space is limited, we cannot guarantee to publish all letters, or to publish long ones in full.

Send your Feedback letters to:

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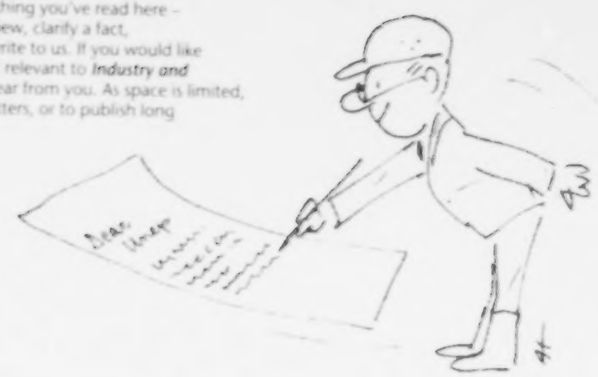

Industry and Environment

a publication of the United Nations Environment Programme
Division of Technology, Industry and Economics

For over 20 years, the quarterly *Industry and Environment* has provided a forum for exchanging information and experience. Articles are contributed by industry managers, government officials, researchers and others active in the field of sustainable industrial development. Besides reporting on developments of broad international interest, each issue focuses on a particular theme. The themes of recent issues have included construction industry, environmental management of industrial estates, product development, industrial accidents, mining, voluntary initiatives, and service industries. For a list of past issues and their availability, contact UNEP TIE or visit http://www.uneptie.org/hp_division_office.html.

The next issue of *Industry and Environment* will focus on sustainable consumption.

Industry and Environment is an English language publication, but it often includes articles in French and Spanish. All contributed articles are accompanied by summaries in English, French and Spanish.

The review is also available in Chinese.
For further details, please contact:
Professor Chen Dingmao
Research Center for Eco-Environmental Sciences
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Industry and Environment
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